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A POST-CARD FROM THE PRESIDENT

GREETINGS:

Being President thus far has been good fun. All of your messages have been filled with best wishes and good cheer. I feel assured that we are to have another successful year, and that our meeting in St. Louis next fall will be a splendid one indeed. I would like our slogan to be, "Make 1936 a Banner Year."

How?

By (1) Inducing other good folks to become members of our association. I am very anxious to increase our membership during the year. If each one of us can convince one teacher of science or mathematics who is not now a member that he would profit by joining our association, we can "double-up" during the year—and that will make it a "perfect thirty-six."
A hint—one of my hobbies is APPLES (Boys and girls is another, and of course my BIG hobby this year is C. A. of S. and M. T.), and Missouri is a pippin of a state for fine apples. Further hint—when you have secured a new member drop me a post-card saying, "I have landed my man," giving his name and address—and at the St. Louis meeting—well, a big, red, juicy, beautiful Stark's Delicious isn't to be sneezed at.

(2) Attending our annual meeting.

(3) Contributing to our journal, *School Science and Mathematics*, by reading it carefully each month, and calling it to the attention of others whom it could serve.

(4) Submitting materials for publication. If "it works" for you, why not help other members of our big family by giving your thoughts wings through the journal?

(5) Suggesting ways of improving our association, that it may better serve the great field of science and mathematics.

May I take this opportunity to express to you my deep appreciation of the high honor you have conferred upon me? I wish to assure you that I will do my very best to merit the confidence you have placed in me?

A HAPPY NEW YEAR to you and yours, including those bright-eyed boys and girls whom you are privileged to direct in the great world of science.

Sincerely yours,
O. D. FRANK

A SHADOW BOX AS A MEANS OF CREATING INTEREST IN SCIENCE

By Hazel Seguin
State Teachers College, Superior, Wisconsin

As one of our teachers entered the lower hall of our building, she remarked, "What a lovely picture!" She walked to the far end of the hall and stood before our Shadow Box. She stooped to read our label: "This Shadow Box is planned and arranged by the Junior High Science Group."

Jane, one of the children, was standing near and heard her exclaiming and admiring the box. Jane came running into my office with a child's happiest smile and saying, "Oh, Miss Seguin, people like our box! Everyone who comes into this lower hall notices it and says something about what a nice idea it is and how much he appreciates what our Science Group is doing for the enjoyment and education of the rest of the children in the building."

Jane was right. Teachers and children alike *were* appreciating the pictures we made with our Shadow Box and were learning something of the joy the group who fixed the box experienced

when they brought in a bunch of new flowers and learned their names and some interesting facts about them.

During the past summer session I used the Shadow Box and found it such a success that I intend to use it during the winter term as well. It creates a real and lasting interest in the subject of science. It makes all the children in the building from the smallest first grader to the oldest child in the Junior High

anxiously await the time when they can take science and learn more about the things they have seen in our box.

During the summer session I used garden flowers and wild flowers for our exhibits. These were changed by the children every Monday, Wednesday, and Friday. The children who fixed the box learned about artistic arrangement of flowers in order to make the picture as perfect as possible. They learned all about the flowers they were working with because they made a label for each exhibit which told the common name, scientific name, and one or two interesting facts which we found teachers and children alike were eager to know about our flowers.

These were some of the labels which accompanied our exhibits of flowers:

COMMON VETCH (Vicia sativa)	IRIS (Iris)	SPIDERWORT (Tradescantia virginiana)
This plant was brought from Europe where it is cultivated for fodder. It is common in the meadows around Superior.	The Japanese have a festival in honor of the Iris in the month of June. On the fifth day of June they hang bunches of wild Iris under the eaves of their houses to ward off evil spirits and to prevent misfortune coming to their homes.	This plant is named for John Tradescant, gardener to Charles I of England.

WOOD LILY (Lilium Philadelphicum)	RUGOSA ROSE
This is one of our wild flowers which should be carefully and sparingly gathered. It is fast disappearing from our thin woods where it used to grow abundantly.	This is one of the many varieties of the rose. Roses have had many uses. In the old days they were used for rose water, rose ointment, rose conserve, sugar of roses, roses kept in wax, rose essence to burn on coals, rose sauce, rose cream, rose tincture, pastels, pastes, syrups, lozenges and cordials. They were also served at the table as cress and parsley are used today, or as a salad.

A light bulb was hidden under the upper inside frame of the box so our picture was light even though the hall was dark. As our principal remarked, we turned a dark dingy spot in the hall into a bright educational corner.

The days on which we were unable to get fresh flowers, we went to our museum for material. We used stuffed birds, mammals, and shells of queer shapes and bright colors. In the fall, I plan to use leaves in all their autumn hues, and plants with prominent seed pods.

For several years I have used the Shadow Box in a corner of my room to create interest in the unit of work which was engaging our attention at the time. We have had fires built by electric lights, red paper and branches, for our forestry unit; we have had the story of limestone as it is built up from the shells, for our geology unit; and we have had the life histories of moths and butterflies and the economic importance of them.

In fact the box can illustrate some principle in every unit taught in general science and biology. It has been so invaluable in my work as a stimulus to interest that I decided to see whether I could interest the entire school instead of just the science classes and I am happy to say that I did. We have made them all science conscious with our simple Shadow Box. The effort has been one-hundred per cent worthwhile.

ON FINGERPRINTS IN NUMBER WORDS

By Luise Lange

South Side Junior College, Chicago, Illinois

"Speak English," said the eaglet, "I don't know the meaning of half those big words, and what's worse, I don't believe you do either."

—*Alice in Wonderland*

All so-called civilized countries have a decimal number system, and most of them have, in accordance with it, decimal systems of units (at least for length, weight, and money). The few countries—U.S. among them—who have so far failed to adopt the metric system, have to pay for their conservatism by all the well known arithmetical drudgery of multiplications and divisions by 9 or 12 or 144 or 36 or 16 or 5280 or 231 or 62.4 etc. where metric countries merely have to shift the decimal point nonchalantly to the left or right.

One might expect that efforts to abolish this troublesome disharmony between a decimal number system and non-decimal systems of units would naturally concentrate on working for the adoption of the metric system; but this is not altogether the case. Suggestions are not wanting to start the reform at the other end, that is, to reform the number system rather than the units. E.g., the *Atlantic Monthly*, some time ago,[1] brought up the issue once again in an article whose author eloquently advocated a *duodecimal* number system, demonstrating how comparatively slight would be the adjustments necessary to transform our decimal into a duodecimal system.

It is the purpose of this paper to show how far deeper cutting the changes are that would truly bring about this transformation than those contemplated in that article as well as in occasional other mentionings of the subject.

We begin by presenting the case of Duodecimal vs. Decimal. The number ten, it is argued, has come into its prominent position as base of the number system not by virtue of any inherent merits of its own, but through the mere anatomical accident of our being endowed with ten fingers. For finger counting preceded the art of arithmetic and came to imprint its pattern on it. Intrinsically, however, ten is poorly suited for its role as base because, being exactly divisible only by 2 and 5, such commonly needed parts of a whole as thirds, fourths, sixths, ninths,

[1] An Excursion in Numbers, F. E. Andrews, Oct. 1934.

and twelfths, when written in the decimal form, lead to terminating decimals with more than one figure, or, to the conceptually difficult and practically unsatisfactory infinite expansions, $\frac{1}{3}=.3333\cdots$, $\frac{1}{6}=.1666\cdots$, etc. For this reason twelve, with its divisors 2, 3, 4, 6, would have made a far better base. The development of the number system in pre-rational ages has prevented it from assuming this privileged position; but wherever men were faced with the problem of actually dealing with equal parts of wholes, namely, in connection with units of measurement, there the superiority of twelve has asserted itself: e.g., 12 inches to a foot, 36 inches to a yard, 12 ounces to a pound (troy weight), 6 feet in a fathom, 24 hours in a day, 12 pieces in a dozen, 12 dozens in a gross. (The 12 months in a year cannot very well be adduced here since they represent the nearest number of lunar cycles in a year; the only possible choice here was between 12 and 13, not between 12 and 10. Also the 360 degrees in a circle have a too distinctly astronomical origin to be classified with the above purely arbitrary subdivisions.)

Having thus inherited the anatomically grounded, impractical base ten for the number system, and the intelligently designed, practical base twelve for units of measurement—*and since harmony between the two bases means the most far reaching simplifications in figuring with units*—we should have been interested long ago in overthrowing that crude, anthropomorphic relic, the decimal number system, and have raised the duodecimal system to the throne. Just the opposite happened when a committee of French savants in the wake of the great revolution forced the units of length, weight, and money under the decimal yoke in creating the metric system, which since that time has been adopted by practically all civilized nations.

This lack of discernment on the part of an earlier generation, however, should not discourage us from keeping the issue alive, from continuing to point out to an unimaginative and conservative world that the traditional number scheme is by far not the best possible one, that it could easily be replaced by the superior duodecimal system.—Just how would the change have to be made? Very simply! The present decimal character consists in this, viz., that the place value of successive digits in a number progresses in powers of *ten*, and that, consequently, we use exactly ten symbols $(0, 1, 2 \cdots 9)$ to write any number. Hence, to change to a duodecimal system place value has merely to be made to vary as the powers of *twelve*, in accordance with which

we would need twelve independent number symbols for the numbers from zero to eleven, e.g. 0, 1, 2 · · · 9, ξ, ϵ. The symbol for the number twelve, under this arrangement, is 10 (one times twelve plus zero); for twenty, 18; for twenty-four, 20; for one hundred, 84; for hundred forty-four, 100, etc. All arithmetical operations would, mutatis mutandis, remain intact; moving the "duodecimal point" would multiply or divide by powers of twelve which was one of the chief advantages we wanted to gain in adapting the number system to duodecimal measuring units (e.g., 123 sq. in. would then equal 1.23 sq. ft., just as in metric units 123 sq. mm. equals 1.23 sq. cm.). Moreover the duodecimal form of the commonly occurring fractions would be considerably simpler: $\frac{1}{2}=.6$, $\frac{1}{3}=.4$, $\frac{1}{4}=.3$, ($\frac{1}{5}=.2497$), $\frac{1}{6}=.2$, $\frac{1}{10}$ (read one-twelfth) $=.1$, etc. To achieve all these great simplifications no more, therefore, is needed than to have people relearn writing numbers. In addition legislators, with the help of a suitable set of "braintrusters," would have to design consistently duodecimal systems of measuring units (for length, weight, money, time, and angles—to make a clean sweep), e.g., twelve dimes to a dollar, twelve pennies to a dime, etc.—and that would be all.

Would it really? With all those adjustments made, would we truly be rid of the curse of our ten fingers and be able to enjoy the benefits of this victory of man's intellectual over his physical nature? *Far from it!* And with this we come to the point we wished to make, namely, ***that our number system is decimal not only because we write numbers decimally, but because we talk decimally as well. Not only our number symbols are patterned after our ten fingers, but our number words are as well.***

Consider for a moment why it is so simple, so natural, so almost automatic to write down, say, the number one-hundred thirty-five in decimal form, 135, and why it seems so far from obvious, necessitating indeed a little arithmetical calculation, to write it duodecimally: $\epsilon 3$, (eleven times twelve plus three). Mere lack of familiarity with the method, with the multiples of twelve? If you think so try a little higher number and see whether you hope, with a little more practice, to acquire enough facility to jot this down duodecimally on mere hearing: two-million three-hundred-fifty-thousand two-hundred-eighty-six. No trouble whatever to spell it decimally! Just write it down as you hear it: 2,350,286. Now try and spell it duodecimally! It is, let me tell you, 945,152 ($9.12^5+4.12^4+5.12^3+1.12^2+5.12$

+2); which it took me about seven minutes to figure out, and even at that I am not absolutely sure that there is not a mistake.

A decimal number language indeed, we talk. Exactly what does that mean? It means this: we use ten independent, individual *words* for the first ten numbers, one, two, three, four, . . ., nine, ten. After that we form words compounded out of these ten indicating addition: one-ten, two-ten, thirteen, fourteen, etc., up to nineteen.[2] A new type of compound number word is next formed out of the original set to indicate the multiples of ten: twenty (two times ten), thirty, forty, up to ninety.[3] The next new, independent number word we use only for ten times ten, *hundred*. After that all number words are again compounded out of the eleven previous ones until we coin another new word for ten times hundred, *thousand;* the next for thousand times thousand, *million* (which, by the way, together with the further, obviously compound formations billion, trillion, etc., is a comparatively recent addition to our number vocabulary).

It is only because of the congruency between decimal number words and decimal number symbols that we so effortlessly write down, say, 567,923, upon hearing the word five-hundred-sixty-seven-thousand nine-hundred-twenty-three. And we shall be able to write numbers duodecimally just as easily if, *but only if*, we first adopt a duodecimal number vocabulary also.

Since there is none in existence we shall have to invent one, which we proceed to do next: To begin with we need twelve independent words for the first twelve numbers. Naturally we use the first ten as they are; and since "eleven" and "twelve" have so largely shed their original compound character we may retain them as well. After twelve we begin to form compound words indicating addition: onetwelve, twotwelve, etc., up to eleven-twelve (which in due time would probably be slurred

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[2] It will at once be objected that we do not say oneteen, twoteen, but that we use, indeed, two more independent number words, eleven and twelve. Linguists, however, tell us that these words are derived from older forms, endleofan or einlif, twolif which did mean one-ten, two-ten—just as the French words onze and douze are derived from the more obviously compound Latin forms undecem, duodecem. One might perhaps regard this tendency to slur down the compound forms one-ten, two-ten to apparently independent words as a "subconscious desire" to count duodecimally up to the full dozen; on the other hand the further formations thirteen, fourteen, clearly indicate that the summation begins after the ten, not after the twelve.

[3] Some European languages, not to mention non-European, show an interesting deviation from this exact scheme inasmuch as an independent word for twenty, and its compounds, appears here and there, pointing to the even more primitive, "bootless" custom of counting by the number of fingers plus toes. The French words for the multiples of ten: *vingt*, trente, quarante, quinze, soixante, *soixante-dix*, *quatre-vingt*, *quatre-vingt-dix* show a strange mixture of the decimal and "vigesimal" principle.

down to something like eltvel). For greater clarity we give below in tabular form the second duodecade of numbers, first in their duodecimal form, both word and symbol, and opposite the same number in decimal form.

duodecimal		decimal	
onetwelve	11	thirteen	13
twotwelve	12	fourteen	14
...		...	
eighttwelve	18	twenty	20
ninetwelve	19	twenty-one	21
tentwelve	1ξ	twenty-two	22
eleventwelve	1ɛ	twenty-three	23

As seen, within each system word and symbol are patterned on each other, the word suggests the symbol and vice versa; whereas no direct relation exists between the word of the one and the corresponding symbol in the other system.

Next we have to invent some word combinations for the multiples of twelve. In analogy to the corresponding decimal compounds we suggest: twendo (for two times twelve), thirdo, fourdo, up to el(even)do.

duodecimal		decimal	
twendo	20	twenty-four	24
thirdo	30	thirty-six	36
...		...	
ninedo	90	hundred eight	108
tendo	ξ0	hundred twenty	120
el(even)do	ɛ0	hundred thirty-two	132

Our first really new word we need is the word for twelve times twelve; let us call it one "*gen*" (symbol 100); the next for the third power of twelve (though in fact, we might call this "twelve gen," just as instead of saying "thousand" we might as well say "ten hundred"); that is, for "twelve gen" we introduce the word one "*dou*"; for the higher powers of twelve, in further analogy to our somewhat arbitrary decimal usages:

$(10)^4$ = twelve dou
$(10)^5$ = gen dou
$(10)^6$ = 1 *mir*
$(10)^7$ = twelve mir
$(10)^8$ = gen mir
$(10)^9$ = mir mir = 1 *bir*
$(10)^{12}$ = mir bir = 1 *trir*, etc.

Designating numbers with these new words we now write them with perfect ease duodecimally; e.g., ten-mir five-gen-threedo-two-dou gen-elevendo-four translates itself automati-

cally into the symbol ξ,532,1ε4; conversely, 94ξ,612 is read off directly as nine-gen-fourdo-ten-dou six-gen-twotwelve. To write or pronounce these numbers decimally, however, would mean the same amount of arithmetical drudgery as does the finding of the duodecimal form for a decimally pronounced number.

Duodecimal arithmetic would thus come not only to *look* different, but to *sound* totally novel as well. E.g.:

first-graders would learn to recite:	writing down on their little slates:
five times six is twendosix	5× 6=26
ten times seven is fivedoten	ξ× 7=5ξ
twelve times twelve is gen	10×10=100
ten times ten is eightdofour	ξ× ξ=84
twendo times onetwelve is two-gen twendo	20×11=220

And just because, and only because, in both speaking and writing duodecimally word and symbol suggest each other this duodecimal arithmetic would be just as simple as our present decimal arithmetic in which we both speak and write decimally.

But to write duodecimally while speaking decimally is like singing a tune in the key of E to an accompaniment in C, like dancing valse to the rhythm of a fox trot, like taking down Russian shorthand after an English dictation.

Any seriously intentioned enthusiast for the duodecimal system must therefore advocate not merely a change in number symbols, not only the adoption of consistently duodecimal units of measurement, but also an almost altogether *new number vocabulary.*

Can we reasonably hope to achieve this reform? Perhaps the committee of French savants in the seventeen-nineties knew what it was doing when designing the metric system rather than proposing a duodecimal number system. Mere written symbols, as experience shows, are changeable with comparative ease, perhaps because of their conscious, rational origins. Language, however, which was not planfully designed but which emerged and grew organically with the race itself is not as lightly routed. Number words, in particular, form part of our very oldest cultural inheritance. Through the ages, through the rise and fall of cultures they have maintained themselves with amazing constancy, so much so that linguists in searching for common origins of languages find number words among their safest guides. To replace them by a synthetic vocabulary would seem, not only difficult, but somehow almost too bad.

Of course dictators of our present-day efficient, not to say ruthless, type could perhaps enforce the change in a comparatively short time, provided they considered the advantages worth their efforts. The irony, however, is, that in all the countries which at this moment have real thorough-bred dictatorships these advantages would be peculiarly small. For all of them, Russia,[4] Turkey, Italy, and Germany do have the metric system which means that they have harmony between their decimal number system and their likewise decimal units of measurement, which is, after all, the chief consideration. Hence all they could gain—and this at the cost of terrific inconvenience—is some fewer and nicer fractions. Nobody then will blame Stalin, Kemal, Mussolini, or Hitler for devoting their energies to even more crying maladjustments.

The countries, on the other hand, which could indeed greatly profit by this reform, in view of the shocking disharmony between their decimal number system and—not even duodecimal, but truly anarchic systems of measuring units, have so far no dictators to force this improvement upon them. Do we expect that these free people will, on their own free initiative, discard not only their number symbols, but their number language as well? Hardly! But what they could do quite comfortably, considering that other free people have done it before them, is to adopt measuring units patterned after the number system they have.

Would it, under these circumstances, not be more constructive for those of us who are justly disturbed over the irrationality of the present arrangement to work in a practical way for the adoption in this country of the metric system? Only then would we begin to enjoy the benefits of that highly ingenious, enormously efficient decimal number system of ours, even though in a corner of our hearts we may continue to regret that the Lord led the human race astray in the very beginning by endowing it with a number of fingers not divisible by three, four, and six.

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[4] To be strictly correct, the metric system in Russia is, at present, "authorized," but not en forced.

If you do not get your journal regularly notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

HEAT YOUR HOUSE WITH A REFRIGERATOR

By G. E. Owen

Antioch College, Yellow Springs, Ohio

A soldier who had seen much service on the muddy fields of France, when asked what was the chief discomfort he experienced, decided after some thought that it was not the mud, nor the noise, nor the danger, nor the bad food, but the "cooties." But even so, he remarked philosophically, "It might have been worse if they were capable of concerted action. There were so many cooties in my blankets that if they had been unanimous they could have rolled me out." Large numbers of small things moving about comparatively at random do not get concerted action unless they do so under the guidance of some controlling force (intelligence, for example) or by chance. Let us imagine that a tumbler full of water is composed of a very large number of small particles of water all in motion in random directions. What is the possibility that all (or a large proportion) of these particles or molecules might have a component of velocity in the same direction at the same time? If the tumbler is allowed to fall, the coordinating force of gravity gives the molecules a velocity towards the earth. But suppose that the tumbler stands on a table, is there any chance that a large proportion of the molecules will get an upward motion at the same instant and that the water will rise out of the tumbler? The practical answer given from experience is that there is no chance at all; the mathematical answer involves the probability that a given number of particles moving at random all have a component of velocity in the same direction at the same time. This probability is not zero, but is so small that it does not enter into our practical calculations.

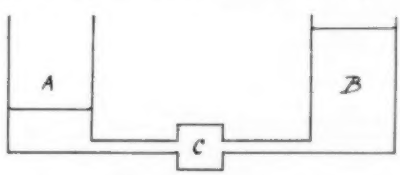
There are many such cases of phenomena which we must assume may possibly take place, but which are never observed in practice. If a tumbler of water is made up of molecules moving at various speeds and the temperature depends upon their average speed, it might happen at some time that the more rapidly moving molecules all gather at one side and the less rapidly moving molecules at the other and a temperature difference between one side and the other would be produced without any heat transfer from the surroundings. It is conceivable that at any given instant the oxygen in your living room might all gather at one side of the room leaving the other side without

any. These are very improbable situations, but there are degrees of improbability. If we ask what is the chance that one half of the living room has 100 more oxygen molecules than the other, the improbability is not very large, i.e., the probability is large and it may and probably does happen very many times. There are, however, some probabilities in a given situation which are larger than all others. In the last example the situation having the greatest probability is that in which there is an equal number of oxygen molecules in each half of the room. In the tumbler of water there is the greatest probability that one side of the water is at the same temperature as the other.

From the very nature of our concept of probability it seems obvious that *natural processes on the average tend to bring a system towards a situation of maximum probability*. This is the most general statement of the second law of thermodynamics. In practice, more restricted statements which are more readily applied to the solution of certain types of problems are commonly used, such as, "It is impossible to obtain mechanical energy from a body by cooling it below the lowest temperature of its surroundings." "Heat will not flow up hill, i.e., from lower to a higher temperature." "It is possible to completely transform mechanical energy into heat but it is not possible to completely transform heat into mechanical energy."

When a natural process takes place in a system (when water flows down hill, or heat flows from a hot body to a cold body), it tends to bring the system to a more probable condition. When a system is in such a condition that a natural process can take place, that process can be used to do work if a suitable machine can be designed for it. When the system has attained its most probable state, it can no longer do work; it has run down. This does not mean that its energy has been used up; it is still there but no longer available for running machines. Consider a very elementary example:

A is an empty tank; B a tank full of water; C a water motor:



water is flowing from B to A through the motor. Assume this system is completely enclosed so that it cannot receive energy

from or give energy to its surroundings. The motor will run until the water level of A and B remain the same. After that the system can do no more work, even though it still has all of its original energy, some of it in the form of heat produced by the motor, some in the form of potential energy of the water. The second law of thermodynamics is sometimes called the law of the degradation of energy, because it says that natural processes tend to make energy less available for doing work. It suggests that the universe is moving towards a more probable situation and that when it reaches its most probable state we can expect no further changes, i.e., nothing will happen, every thing will be still and lifeless.

It is not the purpose of this paper to consider the philosophical implications of this law, but to illustrate and clarify it for students of physical science. An application which is of tremendous practical and scientific importance was that of Sadi Carnot who showed that a heat engine, such as a steam or gasoline engine, cannot use all the heat applied to it. It must not only have a source of heat like the boiler of a steam engine, but it must also have a place into which it discards heat, the condenser of the steam engine or the exhaust of a gasoline engine. He also showed that for an ideal engine which takes Q_1 units of heat from a source or boiler at temperature T_1 on the absolute scale and discharges Q_2 units of heat at a temperature T_2, the ratio Q_1/T_1 is the same as Q_2/T_2. Since the efficiency of a machine is the ratio of the energy it uses to the energy supplied to it, it can be written:

$$\text{Eff.} = \frac{Q_1 - Q_2}{Q_1}.$$

$$\text{Since} \quad \frac{Q_2}{T_2} = \frac{Q_1}{T_1}$$

$$Q_2 = \frac{T_2}{T_1} Q_1$$

$$\frac{Q_1 - \dfrac{T_2}{T_1} Q_1}{Q_1} = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_1}.$$

Thus the efficiency of the ideal engine depends only on the temperatures between which it works. An application of the second

law of thermodynamics will also prove that no actual engine can have a greater efficiency than Carnot's ideal engine.

Lewis and Randall[1] call attention to a very interesting result which follows from the fact that an ideal engine can be reversed so that it takes heat from the condenser and supplies it to the boiler.[2] Since heat will not flow from a low to a high temperature, energy has to be supplied to the engine to make it run in reverse. The ordinary electric refrigerator is an example of an engine which takes heat from the colder body, the inside of the refrigerator and puts it in a body at higher temperature, the radiator of the refrigerator. Lewis and Randal suggest that we heat our houses with refrigerators, that we pump heat in to our houses from outdoors in the winter. This is of course quite possible. If our engines were nearly ideal, it would be a highly economical method of house heating.

Let us assume that we are to heat our house electrically. If we run the electric current through resistance coils, we have almost perfect transformation of electrical energy into heat, almost perfect efficiency. It would seem that a given amount of electrical energy E could not supply more heat energy to the house than E itself. But suppose we use that electrical energy to run a motor which is connected to an ideal engine. Suppose the house is to be maintained at a temperature of 68°F. or 20°C. while the outdoor temperature is that of melting ice, 0°C.

In an ideal engine $\frac{Q_1}{T_1}=\frac{Q_2}{T_2}$ where Q_1 is the heat given to the house at temperature $T_1=20$°C. or 293° on the absolute scale, and Q_2 is the heat taken from outdoors at temperature $T_2=0$°C. or 273° absolute.

$$\frac{Q_1}{293}=\frac{Q_2}{273} \qquad\qquad Q_1=\frac{293}{273}Q_2$$

The heat given to the house is thus 293/273 times as great as the heat taken from outdoors. But the energy supplied to the engine must make up the difference between the heat taken in and the heat given out. Therefore:

$$E=Q_1-Q_2=\frac{293}{273}Q_2-Q_2=\frac{20}{273}Q_2.$$

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[1] *Thermo-dynamics*, Lewis and Randall. Page 131.

[2] "Boiler" and "condenser" are terms referring to steam engines. The terms "heat source" and "heat sink" are more suitable for the discussions of heat engines in general.

Thus the heat taken from outdoors, Q_2, is 273/20 times the energy supplied to the engine,

$$Q_2 = \frac{273}{20} E$$

and the heat given to the house is therefore:

$$Q_1 = \frac{293}{273} Q_2 = \frac{293}{273} \cdot \frac{273}{20} E = \frac{293}{20} E$$

$$Q_1 = 14.65E.$$

If the energy supplied to the house were used to heat a coil of wire at perfect efficiency it would supply E units of heat. If it were supplied to an ideal engine it would give 14.65 times as much heat to the house under the conditions specified.

A GREAT SCIENTIST

Tropical malaria, which has downed so many explorers, has ended the 41-year career of Prof. James Henry Breasted, director of the Oriental Institute of the University of Chicago.

Prof. Breasted, stricken aboard ship as he returned from Egypt, had spent much of his career working along the Near Eastern archaeological front, where he made many important discoveries showing how man rose from savagery to civilization.

As director of the Oriental Institute, called "the largest archaeological headquarters in the world," Prof. Breasted guided far-flung expeditions, as they sought buried history in Egypt, Palestine, Mesopotamia, and Asia Minor.

His contributions to knowledge of the ancient world include:

A two-volume work on the Edwin Smith Surgical Papyrus, which Prof. Breasted translated, showing remarkable medical knowledge possessed by the Egyptians in 1700 B. C.

Directing the salvaging of Egyptian inscriptions, fast decaying on temple walls in Egypt.

Copying and arranging Egyptian inscriptions in European museums, for an Egyptian dictionary.

Writing numerous books, some technical, some popular. Prof. Breasted's broad knowledge of the pageant of early civilization enabled him to write in skillful and vivid style.

Much consulted for his knowledge of the past, Prof. Breasted received numerous medals and other honors. He was a member of the National Academy of Sciences, America's most eminent scientific body, and it was to act as representative of the Academy that he sailed on his ill-fated voyage this past August, to attend the International Congress of Orientalists, in Genoa.

While on this last trip, he arranged with the government of Iran that the 30,000 cuneiform tablets found in Persepolis by one of his Institute's expeditions should be brought to Chicago to be deciphered. That task: will doubtless go on, but without Prof. Breasted's encouragement and aid.—

FUELS

A Contract in High School Chemistry

By Shelby H. Wilson

Marshall High School, Marshall, Missouri

ORIGIN OF THE PLAN

Having used the contract method of instruction a few times with what appeared to be a fair degree of success, it was decided to prepare a contract covering an important phase of chemistry. This decision was reached rather late in the course and a subject was chosen which would not only fit well at that point but would also offer opportunity for the student to make use of his previous training in chemistry.

There appeared to be more interest on the part of most of the students in working out results for themselves than was displayed when the recitation method was used. This condition was noted from the work on previous contracts. Since this was true of more than just the better students, it was thought that a contract would make a fairly wide appeal to student interest.

In addition to the reasons given above for preparing the contract, another reason which deserves some explanation figured largely in the decision to prepare and use a contract.

The town has a college which makes use of the community high school for its practice teaching laboratory. Two chemistry majors were doing their practise teaching there, and it was decided that the construction and "teaching" of a contract as a modern method of classroom procedure would provide valuable training for them.

CONSTRUCTION OF CONTRACT

The contract was constructed by the "student-teachers" working in conjunction with the regular high school instructor who acted in the capacity of supervisor.

The statements, questions, problems, and other material to be included were furnished largely by the student-teachers. These were gone over and the most desirable ones selected by them and the instructor who furnished some of the material.

The items to be included in the finished contract were selected, using the following criteria:

1. Practical application of the item.
2. Contribution to the knowledge of chemistry.

3. Use of previous knowledge and training required.
4. Entirely new items introduced to encourage investigation.
5. Items requiring facts and training from other departments of the school.
6. Objectivity of question.

The last of the criteria mentioned was a bit difficult to determine, as much excellent material for this work could not be entirely objective in nature.

ADMINISTRATION OF THE CONTRACT

There were two chemistry classes of about twenty members each. The work in each class was in charge of the student-teacher with the regular instructor acting as combination supervisor and laboratory assistant.

On the first day the teacher introduced the contract to his class with a few well chosen remarks as to fuels and their importance. These were followed with directions as to work on the contract, a copy of which was placed in the hands of each student. On each day following, some time was given at the beginning of the one hour class period for announcements by the teacher, and a general discussion of such questions as proved troublesome to several students. (A question which troubled a single individual was discussed privately with him rather than to take the time of the entire group.) The remainder of the class period was devoted to work on the part of each student. Considerable liberty was allowed the student as to methods and procedures he might use.

The students were allowed to work in any of the several rooms of the science department which best suited their purposes. Reference books were available in the department as well as in the library. Laboratory work was called for in the contract and this was done at the time the student reached it in his progress through the contract. Students were allowed to work in pairs but not in larger groups. All laboratory work was written up and handed in the day after its completion, when it was filed to be placed with the remainder of the contract on its completion.

Seven class periods of an hour each were consumed by one class in completing all the work called for in the contract. The other group required eight periods. Of course, considerable home work was done by each student. At the close of this work,

an objective test on fuels was given. This test was constructed by the student-teachers and the instructor.

THE CONTRACT

This contract is essentially the same as originally written and used. A few minor changes have been made for purposes of clarification.

A CONTRACT ON FUELS

In this unit on fuels we are to investigate a number of compounds and substances which are of tremendous economic importance. Not only is their production important, but also they enjoy wide use in allied industries. In addition to these facts, their chemistry is most interesting.

This unit takes up the following points:

1. The occurrence and manufacture of various fuels.
2. The chemical processes involved in their preparation and uses.
3. A study of the by-products of fuel production.
4. Practical problems involved in the use of fuels.

Directions to be followed in handling the contract:

1. You will be allowed a reasonable amount of time to complete the work, but there will be no time to waste.
2. All work presented for credit must be neat and in ink; both sides of the paper may be used.
3. Hand in all laboratory work the day following its completion.
4. All calculations on problems are to be indicated.
5. Be sure your name is on every paper you present.

FAIR CONTRACT

1. Name five solid fuels and state the approximate composition of each.
2. Locate the chief coal fields of the United States, telling what type of coal is produced by each.
3. Perform laboratory experiment #1.
4. What are the products of the destructive distillation of coal? State uses for each product.
5. What advantages has the by-product coke oven over the bee-hive oven?
6. What is destructive distillation? How is the ammonia saved in this process when it is applied to coal?
7. Where is natural gas found and how is it obtained?
8. Name three chemical compounds often found in natural gas, and give equations for their combustion.
9. List the steps in the manufacture of water gas, giving equations.
10. What is meant by enriching water gas and how is it accomplished?
11. Calculate the weight of steam that would be decomposed by a ton of red hot coke which is 85% pure carbon, if the reaction is 80% efficient.
12. Explain briefly, and show by equations how producer gas is made and burns.
13. How does the use of producer gas increase the efficiency of many industrial plants?
14. Prepare a table comparing natural, water, producer, and coal gases with regard to heating value, safety in use, and approximate composition.
15. Perform laboratory experiment #2.

16. Write an equation for the formation of acetylene. For what is acetylene used?
17. Acetylene is made by the complete reaction of 50 pounds of calcium carbide. What volume would this gas occupy at 21° C. and 75 cm. pressure if the gas is dry?
18. What weight of air would be required to burn completely 100 liters of acetylene? What volume would this gas occupy under standard conditions? What volume of oxygen would this air contain?
19. What is a hydro-carbon? What is the meaning of the term unsaturated hydro-carbon?
20. Name five liquid fuels.
21. Define fractional distillation. How is it applied in the petroleum industry?
22. Where are the principal petroleum fields of the United States? How did petroleum originate?
23. What is the cracking process? What are some of its advantages?
24. Tell what you can of the different types of gasoline.
25. Distinguish between gasoline and kerosene.
26. Why must care be exercised in the handling of gasoline? For what is kerosene used? What is meant by "explosive mixture"?
27. Draw a candle flame, labeling its parts.
28. Perform laboratory experiment #3.
29. How is fire foam made? For what is it used?
30. What is organic chemistry?
31. Compute the percentage composition of acetylene.
32. Diagram the construction of the Bunsen burner.
33. Draw a simple flow sheet for the preparation of water gas.
34. What element is usually necessary for burning? Define combustion.
35. If C_8H_{18} represents the approximate composition of gasoline, what volume of air would be required to burn a gallon of it, if its specific gravity is .75?

GOOD CONTRACT

1. What is the estimated yield of products from a ton of high grade gas coal?
2. Discuss briefly the paraffin series of hydrocarbons.
3. What is ethyl alcohol? How is it obtained? Name three uses for it.
4. Answer the same questions as in 3 with reference to methyl alcohol.
5. Compute the percentage composition of these two alcohols.
6. What is denatured alcohol? What is absolute alcohol?
7. What is the formula for benzene? Where is it obtained? Why is it an important compound?
8. Perform laboratory experiment #4.
9. Why is more oxygen required to burn acetylene than to burn methane?
10. How many liters of air would be required to burn completely 2.2 lbs. of ethane? What volume of carbon dioxide would be produced?

EXCELLENT CONTRACT

1. Name and give uses for seven coal-tar products.
2. Prepare a map showing the principal coal fields of the United States.
3. Draw the structural formulas for the first four members of the paraffin series of hydro-carbons.
4. What is "blau gas"? For what is it used?
5. Draw a flow sheet of the cracking process.
6. What is fermentation and why is it important?
7. Identify the following chemists with a few words concerning the work of each: Perkin, Acheson, Twitchell, and Kekule.

THE TEST

The following test was used on the completion of the work called for in the body of the contract. The score in each case of the test was the number of correct responses.

Directions: In each of the following statements something is omitted. Fill each blank with the word, phrase or figures which seem to you to make the statement complete and correct. Omissions will be considered incorrect.

1. Name three solid fuels in common use. ________, ________, ________.
2. Where is the chief deposit of anthracite coal in the U.S.? ________.
3. Coal-tar and ammonia are obtained by the ________ of soft coal.
4. The ________ coke oven is more effective than the ________ oven.
5. Natural gas is usually found in connection with ________.
6. Give the balanced equation for the combustion of one of the simple hydro-carbons of natural gas. ________.
7. Water gas is a mixture of ________ and ________.
8. Water gas may be enriched by adding ________.
9. Give a balanced equation for the essential reaction in making producer gas. ________.
10. Write a balanced equation for the burning of producer gas. ________.
11. Compute the percentage composition of acetylene. ________.
12. Acetylene is formed by the reaction of ________ with water.
13. A hydro-carbon is composed of the elements ________ and ________.
14. Write the equation for the complete combustion of acetylene. ________.
15. The formula, C_nH_{2n}, represents what is known as ________ hydro-carbon.
16. Name three commonly used liquid fuels. ________, ________, ________.
17. Crude petroleum is refined by a process known as ________.
18. The yield of light fuels from petroleum is increased by using a process called ________.
19. Petroleum is found in large quantities in what three states? ________, ________, and ________.
20. The physical property of gasoline making it especially useful as a fuel is its ________.
21. Another common fuel, and composed of heavier hydro-carbons, beside gasoline is ________.
22. The luminous cone of a Bunsen flame is due to ________.
23. Organic chemistry is the study of the ________ compounds.
24. A mixture whose combustion is very rapid is called ________ mixture.
25. Alcohol is made by the fermentation of ________.
26. What is the formula for benzene? ________.
27. What important textile treating products are obtained from coal-tar? ________.
28. Draw the structural formula for a simple member of the paraffin series.
29. Calculate the weight of steam that would be decomposed by 1000 pounds of incandescent coke which is 90% carbon. ________ lbs.
30. What are the products of the combustion of gasoline? ________ and ________.
31. Complete and balance the following: $2C_8H_{18}+O_2\rightarrow$.
32. 100% alcohol is called ________ alcohol.
33. The chief use for acetylene at the present time is for ________.
34. Oil fires are usually extinguished by use of ________.
35. What makes water and producer gases more dangerous to use than natural gas? ________.

36. The breaking of heavy molecules into lighter ones is called ______ when applied to crude petroleum.
37. Complete and balance $CH_4+O_2\rightarrow$.
38. Two types of gasoline are ______ and ______.
39. Give a name to the reaction in question #37. ______.
40. Kerosene is sometimes used in place of gasoline because it is less ______.
41. Two natural sources of fuels are ______ and ______.
42. One reason for enriching water gas is ______.
43. The proper name by which to call soft coal is ______ coal.
44. A type of solid fuel for which Ireland is famous is ______.
45. Lignite cannot be shipped satisfactorily because it ______ badly.

Each blank in the above test was counted a response, making a total possible score of 57. The median was found to be 36.5 for the two classes.

GRADING

Although the contract questions were not entirely and absolutely objective, the three instructors agreed upon answers which would be considered acceptable. The score on the questions was the number of correct answers.

The test was easily graded, 36.5 being the median. This score was given a grade of medium and the other scores were marked accordingly.

The laboratory work was graded on a basis of the number of correct responses given on each experiment. The average number of these was used as the median.

All marks were converted to letter grades before being placed in the following form:

Name	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Avg. on Exps.	Map F. Sheet	Cont.	Test	Avg.

The final grade was obtained by averaging the test grade, the grade on the contract questions, and the average of the marks on the laboratory experiments. The map and flow sheet called for in the excellent contract were counted as laboratory work.

If all the work called for in the three parts of the contract was completed satisfactorily, a grade of excellent was given; if the good and fair parts were completed correctly, a grade of superior; for the fair contract alone, a grade of medium.

CONCLUSIONS

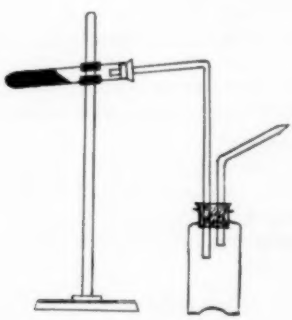
This contract requires the use of several chemistry texts as references, but the material made use of in the contract may be

found in any fairly wide sampling of text and reference books.

To require that all answers conform to one standard would destroy much of the creative on the part of the student. It might lead him to believe that imagination and initiative have little part in the work of modern chemistry. Obviously, in most cases, answers like those in one word completion tests could not be expected. A contract which would be entirely objective would be very useful, but it would also be very difficult to construct without having it consist of merely a group of statements.

The accurate drawing of plates such as that of the cracking process provides good training for those who have had some training in mechanical drawing. This part of the contract may be omitted where no course in mechanical drawing is in the curriculum.

The problem of the student who merely searches for an answer for a given question will arise in work of this type. It may be in part avoided by allowing no quotations and stressing the importance of understanding the material read.



DESTRUCTIVE DISTILLATION—EXPERIMENT 1

An apparatus like the one pictured or a similar one may be used. The tube in which the materials are heated should be of hard glass. Heat slowly at first and then strongly.

A. Wood

Fill the hard glass test tube about $\frac{2}{3}$ full of small bits of wood, and heat.

1. What passes off the wood?
   Try lighting the gas jet of the apparatus.
2. Is any inflammable material produced?
3. Into what is the wood converted?
4. What does a litmus test indicate about the liquid in the condenser?
5. Does there appear to be more than one kind of distillate?
6. What are some products of the destructive distillation of wood?

B. Soft Coal

In the cleaned, hard glass test tube put some small pieces of soft coal. Use a clean condenser bottle.

1. Make a litmus test on the gas coming from the jet. Result?
2. What gas is probably responsible for this reaction?
3. See if any inflammable material is issuing from the jet. Result?
4. What is the material left in the test tube?
5. What is the liquid material in the condenser called?
6. Of what use is coal tar?

METHANE AND ACETYLENE—EXPERIMENT 2

A. Preparation of Methane

Mix about 5 cc. of soda-lime and the same quantity of sodium acetate.

Place in a hard-glass test tube fitted with a one-hole rubber stopper and with a right-angle delivery tube drawn into a jet. Clamp the tube in a horizontal position with the jet tube pointing upward. Heat the tube gently, collecting samples of the gas in a test tube by the downward displacement of air. Test the samples of gas with a flame until the gas is pure and burns quietly. Light the jet.

1. What does the method of collection show about the weight of methane as compared to air?
2. Is the flame of burning methane luminous? Hold a dry bottle over the flame. What appears on the sides of the bottle?
3. Pour a few cc. of lime-water into the bottle and shake. What happens to the lime-water?
4. What does this show one of the products of the burning of methane to be?
5. Write the reaction between lime-water and this substance.
6. Write the reaction for the preparation of methane by this method.

B. Preparation of Acetylene

Fit up a gas generator similar to a hydrogen generator and prepare to collect gas by the downward displacement of water. Into the dry generator bottle place a few pieces of calcium carbide. Add water to the generator through the funnel-tube and collect the gas evolved, over water in test tubes.

1. What is shown about the solubility of acetylene?
   Burn a test tube of the gas.
2. Is the flame non-luminous?
3. Does the gas have an odor?
   Test the liquid in the generator with litmus.
4. What does the test indicate?
5. Write the equation for the preparation of acetylene.

THE BUNSEN BURNER—EXPERIMENT 3

Light the burner and secure a moderately high flame. Close the holes at the base of the burner.

1. What kind of a flame is this called?
   Hold a clean porcelain dish in the flame.
2. What is deposited on the dish?
3. What causes the flame to be luminous?
4. Can you see any cones in the flame?
   Open the holes at the base of the burner.
5. What is the effect on the flame?

6. Does this flame leave any deposit on a dish held in it?
7. Which flame is the hotter?
8. What element necessary for burning enters through the holes at the base of the burner?
   Hold a splinter across the flame near its base.
9. What does this indicate about the inner cone?

THE CANDLE FLAME—EXPERIMENT 4

Light an ordinary tallow candle.

1. How many cones of flame can you distinguish?
2. Diagram the candle flame.
   Hold a small open glass tube in the inner cone and incline it upward. Try to light the upper end of the tube.
3. What does this indicate about the inner cone?
4. What causes the flame to be luminous?
5. Hold a dry bottle over the flame. What is one product of the burning?

AN ELEMENTARY SCIENCE EXHIBIT

The Elementary Science exhibit held in the General Science rooms at Drake University was viewed by approximately 1000 of the 9000 teachers who attended the Iowa State Teachers Association.

Miss Lillian Hethershaw, head of the General Science Department at Drake University, was chairman of the exhibits. About 400 persons attended the program of the Elementary Science section held in the Auditorium at Drake University.

The exhibits and program of the fourth conference of the elementary science section of the Iowa State Teachers Association was held at Drake University, Des Moines, Iowa, November 1, 1935.

The program was as follows:

1. Demonstration Lesson in Science, "Rocks and Minerals in Everyday Life." The pupils were from the 4th grade of the Lincoln School, Valley Junction, Iowa, and the teacher was Miss Illa Podendorf, Supervisor of Elementary Science, Newton, Iowa.
2. "Rocks and Minerals" Dr. H. S. Conard, Grinnell College, Grinnell, Iowa.

Discussion.

Business Meeting.

An exhibit of pupil activities in Science from the kindergarten through grade six from school systems in Iowa was on display in the General Science rooms. The Science units were representative of work from the kindergarten and each of the six grades of the elementary schools. More school systems sent in units of Science than ever before. The following school systems sent in exhibits: Boone, Cedar Rapids, Colfax, Davenport, Grinnell, Knoxville, Madrid (rural), Newton, Waterloo (West).

Books for pupils and teachers were on display on tables and lists of these books for distribution for the visitors.

1. Rocks and minerals.
2. Electricity.
3. Textbooks in Elementary Science (20 different sets).

The Iowa Elementary Science Conference was one of the largest held in the interest of Elementary Science in recent years.

THE USE OF A LIGHT INTENSITY METER

By Erwin Miller, Jr.
University of Southern California, Los Angeles

A number of studies of light intensities have been carried on by means of instruments which were, in general, open to criticism because they measured either only a portion of the visible spectrum, or the entire range of solar radiation, and were too complicated and delicate for some types of use, especially for field work. The recent development of a photoelectric photometer which combines low cost, portability, and simplicity of operation, with sensitivity to light waves of the range of the visible spectrum, has made more practicable the study of light intensities in the field and elsewhere. The construction of this type of photometer is explained in the article by L. Cushman, "A Light Intensity Meter for Field Use," in the December, 1933, issue of School Science and Mathematics.

Because of the utility of this instrument it has been thought best that proper methods of operation, with a knowledge of its possibilities and limitations be established. For botanical investigations the photometer is particularly good since it gives intensity readings which closely approximate visible intensity, which has been shown to be of chief importance in plant life. Wherever this range of intensity needs investigation, the applicability of the instrument is equally great. It has the further advantage over many other types of photometers of presenting results in terms of a definite unit, the foot candle.

Photochemical and thermal methods for the measurement of light intensity are described by Klugh (1925) and Shirley (1930), while Hughes and Dubridge (1932) adequately describe photoelectric methods.

In this paper the Cushman type of instrument is briefly described, a correction formula for the effect of temperature is developed, the inaccuracies entering into the operation of the instrument are enumerated, and the final method of use is stated.

THE INSTRUMENT

This photoelectric photometer employs as its light-sensitive element a Weston Photronic Cell,[1] which was chosen because its maximum sensitivity occurs fairly close to the maximum of

[1] The Weston Photronic Cell No. 594, Weston Electrical Equipment Co., Newark, New Jersey.

visible light intensity, and because the electrical current generated is great enough not to need amplification. For ordinary use no filter is necessary, and in many special cases its addition is not needed, since it can be shown that the areas of a cell response curve on either side of a curve of visible intensity are more nearly equal without the filter than with it. Red and blue filters are necessary in studies of selected red and blue bands of light. When it is desired to investigate maximum intensities, a Corning filter[2] should be employed, since by its use the maximum intensities for the curves of visible intensity and photoelectric cell response may be made to approach coincidence.

The electrical current generated by the conversion into electrical energy of the radiant energy incident upon the sensitive element of the photoelectric cell is read on a microammeter, and by reference to a calibration graph determined for the particular Weston Cell in use, the reading in microamperes is read as light intensity in foot candles. The calibration graph mentioned may be converted into a table for convenience and rapidity of use.

Though it was known that the electrical output of the photoelectric cell varied with the temperature at which it was operated (Technical Data—Weston Photronic Cell, 1933), because of the approach of the curves given in the above publication to the horizontal with increasing light intensity, it was supposed that the variation due to temperature at the intensity of full sunlight would be negligible. When the cell was used on the warmer days of summer effects were noted which could be accounted for only by variation due to the temperature of the cell. So a curve was constructed, using a 200-watt Mazda lamp as the source of both light and heat, the electrical current being supplied by a 120-volt storage battery because of the variable voltage of the ordinary lighting circuit. As the temperature could not be reduced below room temperature in summer, it was possible to plot only a portion of the curve covering a range of 20 degrees Centigrade. This was sufficient to give the direction of the curve but not its shape. Because the curves published by the makers of the cell approach a straight line with increase in intensity, and because experimental evidence of the actual shape of the curve was not available, it was drawn as a straight line. The change in electrical current output of the cell was found to be 0.37 per cent per degree Centigrade at the in-

[2] Corning Glass Co., Corning, New York. Heat absorbing, heat resisting, dark shade.

tensity of about 6,500 foot candles. To correct readings when the temperature is taken, the following formula may be used.

$$I=(t-23.75)K+I'$$

I is the corrected intensity; t the temperature at which the cell operates; K the difference in foot candles per degree Centigrade, determined from the percentage of change at each intensity; and I' the recorded intensity. 23.75 is the degree Centigrade above which the indicated intensity is lower than the actual intensity (with the reverse occurring below 23.75 degrees Centigrade).

There are places where error might enter into the operation of the photometer. The cell itself, the calibration of the electrical current generated by the cell against light intensity, the construction and reading of the calibration graphs, the change from one set of resistances to another through the photometer's range of intensity, the fatigue effect of the cell, and the effect of temperature on the current output from the cell—these constitute possible sources of error. The manufacturers of the photoelectric cell state that the cell itself has an inaccuracy up to 2 per cent. The calibration of the photometer has now been checked against a standard light source with controlled voltage, and the calibration was found to be only slightly inaccurate, the major inaccuracy being one of 4 per cent. The change from one set of resistances to another by means of a switch provides a constant and easily measured error. The change from tap 1 to tap 2 on the instrument used involves an error of 6.1 per cent, from tap 2 to tap 3 an error of 1.5 per cent, and from tap 3 to tap 4 one of 2.5 per cent at low intensity and 2.0 per cent at high intensity. With the exception of the first mentioned, the amounts are so small as to be negligible. Because of the slight variability in the construction of the resistances, this error cannot be eliminated. These two latter errors due to calibration and change from one tap to another are constant.

The fatigue effect of the photoelectric cell is estimated by the manufacturers to be 3 per cent, which would become constant in about three minutes at intensities under 300 foot candles. When full sunlight is used, this figure is doubtless too small. Experiments with a constant light source at intensities of from 4,000 to 6,000 foot candles indicate that this fatigue effect amounts to around 14 per cent, and is overcome in four or five minutes at these intensities. Unless the cell has been completely

shaded before a reading is taken, or exposed long enough for the fatigue effect to be overcome, it is impossible to estimate the error involved. In actual work where the cell was exposed constantly for several minutes, the attempt was made to expose it to the light long enough to permit the effect to be overcome and the reading to become constant before the recording of intensities was commenced. With this precaution it may be assumed that the error is constant.

THE METHOD

In order to make uniform the conditions under which readings were to be taken, it was decided that the face of the photoelectric cell should be placed horizontally rather than in any other position. This eliminates reflection, giving a reading of direct plus diffuse light, and makes data collected in this manner somewhat comparable to data obtained by the use of standard pyrheliometers. Care was taken in obtaining all readings that nothing should cut off direct or diffuse light from the cell. In order to get the effects of the ascension and declension of the sun reduced to a minimum, readings for comparison may be taken during the period from 11.00 A.M. to 1.00 P.M. This is based upon examination of pyranometer records and is borne out by readings made with the photoelectric photometer in the course of experimentation.

For a series of readings 15 second intervals were tried, but as it was found that the variation between the medians of 15 seconds and 1 minute intervals was only about 1 per cent, 1 minute intervals were adopted, with the face of the cell exposed during the entire time of reading. In some circumstances, however, in order to indicate certain climatic variations, 15 second intervals have been employed.

In representing the acquired statistics graphically, the median was chosen as the means of expressing central tendency rather than the average, because the distribution of the readings did not approach normal frequency except in a few instances. For the same reason the standard deviation as the expression of dispersion was abandoned and the range P_{15} to P_{85} used in its place. Curves were smoothed by the calculation of sliding averages, and correlations were made by the Pearson Product-Moment method. The slide rule was used in calculations, its use being justified by the variables influencing readings.

The usefulness of this type of photoelectric photometer has been demonstrated by its employment over a couple of years in the field and indoors, and its best method of use may be readily acquired.

This work has been carried out under the direction of Dr. H. de Forest in the Department of Botany, University of Southern California, Los Angeles.

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FINIS-STAGE TWO

With the successful cooling of the great 200-inch diameter block of glass for the new California Institute of Technology's future telescope, stage two in one of the most gigantic enterprises of science is now complete.

Stage one was the extensive experimentation in pouring and casting smaller disks of glass which served as trial horses for the now-completed 200-inch giant.

Stage three will be finished, it is hoped with equal success, five years hence, when the huge glass disk is finally installed in the observatory on Mt. Palomar, some 75 miles from Los Angeles.

The coming five years will be filled with intensive work in what astronomers call the surfacing of the disk; the gentle grinding of its level surface into a depression of complicated curvature which will gather and focus light that started out from distant stars millions of years ago.

The delicate grinding must make the surface accurate to a few millionths of an inch.

And while the slow careful grinding is going on, other workmen by the score will be busy. The steel framework for supporting the mirror, so delicately poised that a hand can move it, must be finished by the time the grinding is complete. The great dome of the observatory—the thing which most impresses the layman—must be finished in time to house the whole project. And scores of auxiliary apparatus must be fabricated, including the giant vacuum tank in which astronomers will coat the completed mirror with an aluminum reflecting surface instead of time-honored silver.

The great mirror, keystone in the whole $5,000,000 astronomical project, will be shipped, one can be sure, with all the gentleness which characterizes a train when the president of the road has his private car on the rear.—*Science Service*.

HOW TO INCREASE THE LABORATORY EQUIPMENT

By Eldred R. Harrington
Albuquerque High School, Albuquerque, New Mexico

The writer was an engineer and machinist before entering school work so naturally sought to supplement the inadequate physics equipment with some home-made apparatus. A systematic appraisal of the high school janitor's "junk room" resulted in the starting of several pieces of apparatus. Similar trips were made through the junk piles accumulated at other schools in the system and finally our journeys even led us to the local electric companies and to the railroad shops. The writer at first conducted the "instrument making factory" by himself but he soon enlisted the cooperation of the manual arts department and at the present writing most of the work is done there. It might be of interest to know what some of the projects have been in this work.

Three motors were obtained from the school junk-room to begin with. They had been burned out and junked years before. The writer re-wound these motors by the aid of a book and they ran well enough, somewhat to the surprise of the writer and his friends.

The source of current for many experiments had been the dry batteries which were unsatisfactory and short lived. Step-down transformers would serve in many cases so three of these were constructed from the available insulated wire wound on cores made from strips cut from stove pipes. These transformers furnished current at 12 and 20 volts pressure. A step-up transformer having a secondary voltage of 1200 was then made and was shortly followed by a large welding transformer made in the school shops. The schools in the city system changed their bell systems about the same time, removing their old storage battery and rectifier system and replacing it by an alternating current system. The battery jars and rectifiers were quickly pounced upon by the high school science department and the question of current, either A.C. or D.C., is now solved.

Electromagnets came next. One three-inch electromagnet made in the school shop has a lifting power of 200 pounds. It was built at a total cost of 18 cents. Choke coils, two rheostats, two condensers, and a Tesla coil followed. A sucking coil was wound and used to remagnetize a number of permanent mag-

nets which had become dead after many years of use. The school shop next contributed a pair of Magdeburg hemispheres, an air compressor, an air blower, a centrifugal pump, a steam boiler with steam engine and generator attached and a model lifting crane. These pieces of apparatus are not makeshifts by any means but well built machines which will last for years and also be first class examples of work done in our machine shop by our own students.

When patterns are needed they are made in the school wood work shop. Castings are made in the small experimental foundry. Sheet metal work is done in the auto mechanics shop under the expert direction of a man who has years of experience in such work. The writer's work has been transferred to more capable hands and the apparatus being turned out at the present time is well worthy of display. The metal work classes have even taken old brass door rods and cut them down into 10, 20, 50, and 100 gram weights which have been standardized against corresponding weights of an expensive set.

The manual training department took lumber from packing cases and made test tube racks, and small pieces of wooden apparatus. The department also contributed several parallelogram of force boards, two book cases, a display case, a 22.4 liter box, a sonometer, a resonator for tuning forks, racks for experiments, gyroscope turntable, a color wheel, persistence of vision apparatus, etc. Their most recent contribution is a table on wheels which may be pushed from one room to another and used as a demonstration desk for classes in physics and chemistry.

One of the city's foremost radio "fans" donated to the school a large number of radio parts. Student "fans" have made two receiving sets and a sending set for the department. A bicycle shop furnished a wheel which became a gyroscope after being weighted by a lead pipe furnished us by a local plumbing shop. The bicycle shop also furnished us a number of bicycle spokes which are much superior to knitting needles and clock springs for use in magnetism experiments. We obtain our supply of horse-shoe magnets from the local garages and one shop has even saved up a large supply of iron filings for us. We find that the various business houses are very willing to do such things and it lets them know that we are alive and carrying on.

Our cooperation system is not limited to the manual arts department alone. Up to date, practically no department of the

school has been omitted from our calculations. Our tests are typed and mimeographed by the commercial department. This department has also shared with us their timing devices such as stop-watches and metronomes. The art department quickly responded to our call for color charts and pictures for our persistence of vision machine. The music department has been called on frequently during the study of sound. The home economics department saves scraps of cotton and wool for the dye experiments in chemistry and felt scraps for the electrification of non-conductors. They have freely loaned their electrical apparatus when we needed it for testing purposes. They have also baked the insulation on to some of our home-made electrical apparatus.

The printing department prints all of the experiments used in physics and chemistry. They have repaired our books and printed the rating sheets. Their copper and zinc cuts are turned over to us. The copper cuts make good voltaic cell plates and the zinc cuts are melted down and poured into water to produce mossy-zinc which is to be used in making hydrogen.

The writer has read about lack of cooperation in certain school systems but this lack is certainly not felt in the Albuquerque schools. Practically every school in the system has contributed something to our program. In no case has the writer ever been turned down on a request for aid. On the contrary, he has usually received more help than he expected in each case. The same statement is true of the aid received from outside of the school. This cooperation has been most gratifying to the teachers and has also aided in building up student interest. It is interesting to note that the enrollment in physics has increased more than 300 % since this plan was inaugurated five years ago.

Repercussions of the discovery of heavy water in the science of biology were described to the meeting of the American Physical Society, November 29.

Extremely delicate tests checking the effects of powerful drugs and poisons on the animal and human body must now be carefully watched to see what kind of water is used for making the weak testing solutions, said Dr. David I. Macht, pharmacological scientist of Baltimore. The solutions, Dr. Macht explained, are injected into animals and their effects studied. What complicates these biologic tests, says Dr. Macht, is his discovery that the effects obtained depend on how much of the water in the solutions is of the heavy variety. If only one part in 2000 of the water is composed of the heavy kind, such important biological products as enzymes react in a vastly different way than they do normally.—*Science Service.*

KEEPING THE SCIENCE ROOM INTERESTING

By Dennis Glen Cooper

Sherrard Intermediate School, Detroit, Michigan

Much of the success in science teaching depends upon the pupil's mental attitude while in the science room. A pleasantly attractive room helps greatly to condition this attitude favorably; it stimulates the pupil to put forth sincere efforts and helps to develop a keener interest in the whole field of science. "Attractive physical surroundings have an especially strong influence on pre-adolescent and adolescent youths."[1]

But the science room should be *instructive* as well as *interesting*, and it is the writer's feeling that the science teacher should plan to meet both these requirements in as many ways as possible: materials *educational* in themselves should be so used as to offer great *stimulation* to the eager, impressionable minds of adolescent youngsters. At the Sherrard Intermediate School in Detroit we have tried to arrange one of the general science rooms so as to aid in fulfilling both these objectives. It is with our efforts, methods, and results that this article will deal.

The research herein described was begun some years ago, and has been continued with increased enthusiasm and more satisfying results until now a very elaborate program is in effect. Our first efforts were directed toward learning what kinds of attractions brought forth the most evident signs of interest from the pupils. We found after continued observation that no one kind interested all children alike, but that all seemed to enjoy a variety of exhibits, such as well-arranged bulletin boards, experimental apparatus, special table and wall-case displays, and particularly living plants and animals—provided enough time was given for them to examine, interpret, and enjoy what they saw. To provide all these things takes a great deal of time and effort, but we arrived at a plan of using pupil-assistants in such a way that the room could be kept in excellent order with only a moderate expenditure of effort by the teacher. At the same time a number of boys were given an opportunity to engage in creative, cooperative work with teacher and classmates which was of great benefit to the school besides providing an excellent opportunity for character development.

[1] Davis, C. O., *Junior High School Education*, World Book Co.: New York, 1924, page 40.

Most of the work of caring for the room is done after school hours by the teacher and pupil-assistants. Our experience has shown that for a number of reasons it is wisest to enlist for this work the services of ninth grade boys who have expressed a desire to help in the science room. Those who prove to be intelligent, efficient, cooperative workers are asked to report frequently, perhaps three nights a week; whereas those who do not seem so capable are called upon whenever needed, the work they are given being so adapted to their individual abilities that they feel a sense of joyous satisfaction at its accomplishment. The boys who become "regular" assistants are asked to bring notes from home giving the parents' consent to their remaining after school hours to do this kind of work. It might be mentioned incidentally that we never have a dearth of assistants as there is always a waiting list of eighth grade lads who hope to become assistants in their last year with us.

After school the science room is a scene of busy and varied activity. All the boys have regular tasks to perform and it is to these that they give their immediate attention. When their tasks are accomplished they ask for further direction. If there is nothing more they may go home, help their friends, or visit until the group leaves. But there is usually enough to keep them occupied for some time; often, even when not given specific instructions, they will find something with which to busy themselves, each trying to do his share to make the room tidy and interesting.

The pictures on the two large bulletin boards in the room are changed weekly. Usually there can be found one or two boys among the helpers who have a good sense of balance and who, if given general directions, can produce some strikingly artistic results. The materials used are from the writer's own collections and from the Detroit Children's Museum, which supplies pictures and exhibits upon request. These displays are arranged to correlate with the work being studied by the classes at that time. The boys are told what the nature of the exhibit is to be, and are then left to work out their own designs. A few of the many topics that have been well illustrated on the bulletin boards are the following: signs of spring, superstitions, primitive man, fossils and fossil-hunting, scientific laboratories, great scientists, looking into the heavens, man's use of power, transportation, wonders of electricity, false science, sources of our clothing, good foods, patent medicines and quack doctors,

sports and exercise, Christmas, Mother's Day, Washington's birthday.

Some boys like to arrange table or wall-case exhibits. These too are made up of the writer's or of Museum materials, and are made to correlate with the classwork, but usually they are changed bi-weekly. Typical exhibits are the following: fur-bearing animals, rocks and minerals, insect life, trees and leaves, invertebrate or vertebrate animals, fibers and cloth, handiwork of different countries, building materials, properly-set dinner table, fuels. These exhibits, like the bulletin board displays, are made up of materials *educational* in themselves, *attractively* and *intriguingly* arranged.

Still other boys enjoy setting up experimental apparatus. Particular interest is always aroused by the set-ups involved in experiments concerning the generation and testing of oxygen

FIG. 1. View of some of our exhibits of living materials.

and hydrogen, food testing, air pressure, osmosis, magnetism, simple machines. In the preparation of these materials there is necessarily more teacher-supervision, although even here the boys are left "on their own" as much as possible.

The living materials kept in the room constitute by far our greatest attraction; consequently we feel that they merit a correspondingly greater amount of time and energy (Fig. 1). It is obvious that pupils like living things; but more than that, plants and animals can be used much more effectively in the teaching of biology or nature study than can charts, pictures, or preserved specimens. They make biology truly the science of *life.* For these reasons we have been anxious to learn what specimens will thrive in a school room.

The results of several years of experimentation have been very gratifying. During the past year we successfully kept the following for study or as pets: balanced aquaria containing va-

rious kinds of plants, fish, snails, clams, and crayfish; tropical aquaria, kept at the proper temperature by a thermostatic electric heater; bog, woodland, and desert terraria containing newts, salamanders, frogs, toads, insects, turtles, snakes, and lizards; alligators, singing canaries, white mice, white and hooded rats, "waltzing" mice, kangaroo rats, squirrels, guinea pigs, and rabbits.

Many of the creatures that have just been mentioned are brought in by pupils, some are caught in the open or acquired from a local pet store by the writer, while many excellent specimens are purchased by the school from the General Biological Supply House, of Chicago. As a rule, our aquaria are purchased, but most of the animal cages are planned and made by the

FIG. 2. Cleaning and feeding time.

pupil-assistants after school in our wood shop. These cages must be kept clean. Every two days any refuse is taken out and the cage bottoms are covered with sawdust or shavings from the wood shop (Fig. 2). Aquaria and terraria are set up by the assistants, and then watched carefully in order that any dead materials may be quickly removed (Fig. 3).

A variety of food is required to keep all these animals healthy. Some kinds are purchased, some brought in by pupils; and a good supply of such foods as cabbage and lettuce leaves, carrot tops and apple peels is sent to us from the school lunch counters. In most cases we have worked out our own diets; in others, full information for the care of certain animals has been obtained without cost from the General Biological Supply House. Food and fresh water are supplied daily by boys especially appointed

for this important task. During vacation periods assistants living near the school care for plants and animals, while in the summer they take most of them home. A few specimens, more difficult to feed or handle, are looked after by a local pet store.

Our next important consideration concerns the uses to which all our equipment is put. It would be wasteful indeed if all this energy were expended without definite provision of opportunities for the pupils to examine and enjoy the various attractions in the room. A plan has been worked out to answer this need.

The writer has long felt that we really expect a great deal when we ask our pupils to pass from one class to another in a quiet and orderly manner and immediately get down to their

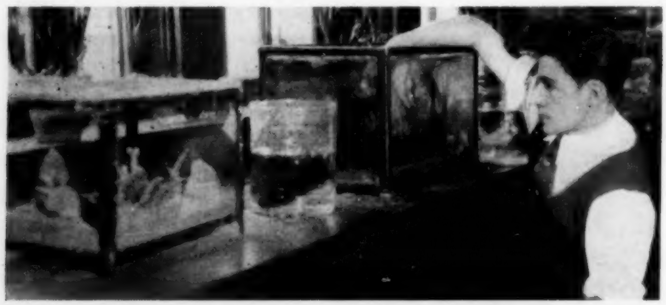

FIG. 3. An assistant setting up a balanced aquarium.

tasks with enthusiasm, in utter forgetfulness of the work of the previous period. These children are adolescents, full of vitality and a multitude of interests! They are experiencing emotional drives which speed up the entire tempo of their lives. With this thought in mind, the writer has attempted to adjust his class procedure to fit more closely the needs of these vivacious, enthusiastic, imaginative boys and girls. At the beginning of the class period the pupils, upon entering the room, are not required to sit down and quietly await the pleasure of the teacher; rather they are encouraged to wander about the room to inspect whatever interests them. They may look at bulletin boards or special posters, at exhibits, or experimental apparatus; they may rush to visit their animal friends or examine some plant which fascinates them; they may talk with the teacher, or with each other. Of one thing they are sure: there will always be something new and interesting awaiting them in this room.

For five minutes or so they move about the room, inspecting,

admiring, gazing, wondering; touching, talking, laughing, enjoying (Fig. 4). Then the teacher, who has been watching the proceedings unobtrusively, pushes the button of an electric buzzer near his desk, which is the signal for the class to come together. The work of the day begins. But these children do not now need to be stimulated, to be told that they are in a general science room, ready for a science lesson. Their free period has accomplished that, and they are now "all set and ready to go."

But the activity does not stop there, for numerous devices

FIG. 4. Looking things over during the free period.

are introduced to help sustain the enthusiasm that has already been aroused by the introductory period. First of all, the classwork is generally carried on following the socialized recitation method for we believe, as does Davis, that the "socialized recitation is the most desirable type of recitation period for the junior high school."[2] Then, the bulletin boards, exhibits, experimental apparatus, and living materials are all made an integral part of the class discussion, while motion pictures, slides, charts, records, work with the microscope, special reports, dramatizations, and teacher-lectures help further to vitalize the instruction. Activity and variety are ever the keynotes of our efforts.

It may be said that all this requires a great deal of time and

[2] Ibid, page 111.

effort on the part of the teacher. It does. But we do not wish to imply that *all* these attractions must be included in every general science room in order to make it interesting: we have desired simply to indicate some of the directions in which our efforts have taken us, with the hope that others may find some ideas or activities herein described that they may care to pursue further and adapt to their own purposes.

Even if some extra work is involved, however, the joy and satisfaction that one derives from looking daily into the happy, eager faces of a room full of appreciative youngsters makes the price seem low. Perhaps no one has better expressed our feelings on this matter than Overstreet when he writes that one of the highest levels of self-fulfillment exists "where the line between leisure activity and work activity has altogether disappeared, where the work, in short, has been so entirely identical with the interest and powers of the individual that it has constituted his most essential life. This . . . is the condition . . . where work is play and play is work. . . . For such an individual there is no problem of leisure, for leisure is lifted up into a life creatively integrated, and there is no problem of work, for work is a beloved activity for which even a long life is all too short."[3]

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[3] Overstreet, H. A., *We Move In New Directions*, W. W. Norton & Co., Inc.: New York, 1923, page 238.

SMALLPOX, TYPHUS AND RELAPSING FEVERS EPIDEMIC IN ETHIOPIA

Death and disease are No. 1 enemies along the impending Italian-Ethopian battle lines. Reports on disease conditions in Addis Ababa as communicated in consular reports to the U. S. Public Health Service here read like the index to a medical book.

Epidemics of typhus fever, relapsing fever and smallpox are harassing the Ethiopian capital and surrounding country, according to the latest report. The number of cases or even of deaths in these three epidemics is unknown, as no statistics on sickness, deaths or births are collected. Vaccination against smallpox is not practised.

Leprosy is very common in Ethiopia. So are venereal diseases, and syphilis is reported to be more prevalent there than in any other country. It is said that 90 per cent of the adult population is affected by some venereal disease. Malaria of course is always present. Tuberculosis, grippe, pneumonia, quinsy, asthma and dysentery are other diseases reported prevalent. Practically all the adults in the country have tape-worms.

Cholera and plague are not mentioned in the consular reports, and Ethiopia is out of the yellow fever and sleeping sickness regions. But as one health official put it, if these four diseases are not present in the country, they are about the only ones the Ethiopians do not have.

THE CHEMISTRY OF ANALGESICS

By Sister Antonius Kennelly

The College of St. Catherine, Saint Paul, Minnesota

Analgesics belong to the large class of drugs which act on the brain and spinal cord to decrease consciousness. They temporarily cut telephone connections between the various sense organs of the body and the brain or they lull the operator into an unresponsive state so that protests do not register. Mildest of this group of drugs are the sedatives, which as their name implies, quiet nerves, paving the way for sleep. The chemicals known as bromides were for a long time the chief sedatives. Now luminal and related drugs have superseded them. Next come the hypnotics, the real friends of the insomniac, which trick him into an artificial sleep, then turn it into a natural one and permit him to wake refreshed—sometimes. Sleep like this can be purchased under many names—unfortunately—as we shall see later. But the hypnotics are of no avail if the sleeplessness is due to pain. Here the analgesics, our third group, have their inning. Sometimes by allaying pain, they make sleep possible but this hypnotic effect is merely incidental. They include the long known opiates, from the poppy fields, as well as the newer coal tar analgesics from the chemist's laboratory. If a drug is strong enough not only to relieve pain but also to cause unconsciousness and complete muscular relaxation, it classifies as an anesthetic. The fifth group of drugs, the intoxicants, include alcohols which anesthetize, too, but slowly, having a longer excitement stage than the drugs regularly classed as anesthetics. Of these five classes of drugs, sedatives, hypnotics, analgesics, anesthetics, and intoxicants, all of which act as depressants on the central nervous system—the analgesics will be singled out for discussion here.

Oldest and best of the analgesics, for severe continuous pain, are the opiates. These belong to the larger group of drugs, the sale and use of which are regulated by the Harrison Federal Narcotic Act. In spite of the danger of habit formation connected with them, opium derivatives are still indispensable not only as analgesics, but also in larger doses as hypnotics, when the newer chemicals fail. They also fill a definite place as aids to regular anesthesia. Incidentally, a new opium derivative, dilaudid, has been made, for which it is claimed that danger of addiction is at a minimum. Synthetic analgesics, those which

are purely laboratory products, surpass the opium derivatives in only one respect, the relieving of intermittent pain. The development of this latter group of analgesics was hailed with delight as providing a means of alleviating pain without danger of drug addiction. That unforeseen and extremely serious hazards attend their use has only recently been definitely shown. Before we can go into this, however, we must retrace our steps over the field of cerebrospinal depressants to see just what connection there is between the chemistry of these drugs and their physiological effects.

In his quest for substitutes for the dangerously habit forming drugs, the chemist first studies the nature of those substances which have known sedative effect. He finds, for instance, that the members of one group all contain the element bromine. Evidently bromine has the power of quieting nerves in the absence of pain. Then the chemist looks about to see if other substances besides bromine decrease the activity of the nervous system. Drawing on the experience of the race, he decides that ethyl alcohol—ordinary grain alcohol—must contain some atom or group of atoms that causes an eventual decidedly hypnotic effect. Investigation reveals that there is no bromine in alcohol but there is a certain combination of carbon and hydrogen atoms, two of carbon with five of hydrogen, which may be responsible for this effect. This particular combination, known as the ethyl group, occurs twice in the molecule of ordinary ether, a product of the laboratory used as an anesthetic for nearly the last 100 years. Obviously this group has an affinity for the nerve tissues of the body. Further evidence of this is afforded by the fact that certain dyes containing ethyl groups will dye nerve fibers but if these ethyl groups are replaced by other groups, the same dyes fail to color the nerve fibers.

Still another combination of atoms, namely, two nitrogens with four hydrogens, a carbon, and an oxygen, as found in the molecule of urea, one of the waste products of the body, is also observed to have a sedative effect. Now since it is the work of the creative chemist to combine and rearrange atoms at will—it is natural that he should follow up his observations on the sedative and hypnotic effects of these particular groups of atoms with attempts to make new drugs out of them, possessing all of the virtues and none of the vices of those occurring in nature. Step by step he builds up new compounds, introducing a sedative or hypnotic group now here, now there, knowing that the

potency of his drug product will depend on many factors. The effect of the *number* of hypnotic groups in a drug is illustrated by the sulfonals. In these, ethyl groups may be multiplied until four have been introduced, making tetronal, and the result is dangerously toxic, whereas sulfonal itself with two ethyls is quite safe. Not always will an increased hypnotic effect accompany the combination of different hypnotic groups. For instance, the union of bromine with ethyl and urea groups in carbromal provides us with a hypnotic which is much less powerful than other ureides.

The chemist's manipulation of the ureides, or barbiturates, as they are commonly called, has led from one brilliant achievement to another. Veronal, or barbital, is probably the most valuable of the barbiturates. Two ethyl groups in addition to the urea arrangement of atoms may be responsible for its sleep producing effect. Emil Fischer, perhaps the greatest organic chemist the world has known, prepared this first *true* hypnotic in 1903. The intervening thirty years have witnessed the creation of a long series of barbiturates with many varieties of substitutes for one or both ethyl groups of Fischer's product. Of these phenobarbital (luminal) which contains a special group of six carbons and five hydrogens, called the phenyl group, in place of one of the ethyl groups, is even more effective than barbital in special cases where nerves refuse to behave properly. Another, amytal, is not only a desirable sedative and hypnotic but is also finding a place as an anesthetic. Evipal, a relatively new member of this group, is comparatively brief in its effects and has therefore proved very useful for patients who can sleep naturally, once they have been put to sleep. Others again of the barbiturates are employed as analgesics in migraine, neuritis, and kindred disturbances.

Turning now to the group of chemicals made in the laboratory which are purely analgesics, we learn that they were discovered by accident, in the course of a search for a quinine substitute. Their source is aniline which is obtained from coal tar. Aniline itself contains the phenyl group already mentioned, a nitrogen, and two hydrogens. Incidentally aniline forms the basis of a large group of dyes, as well as of the medicinals under consideration here. The grouping of atoms due to the aniline base is sometimes referred to as the benzamine ring or phenylamine group. We might pause to recall here that the barbiturates also contain nitrogen in addition to carbon, hydrogen, and

oxygen. This is likewise true of the opiates. The first of the coal tar analgesics to be prepared was found to be capable of reducing fever and hence was called antipyrin and the whole group is often called the analgesic antipyretic group. The analgesic property, discovered later, has now become the more valuable characteristic. They relieve some types of neuralgic pains where even morphine fails. Acetanilid, now little used because of its greater toxicity, phenacetin, and amidopyrine are the best known members of the analgesic antipyretic family. Amidopyrine, or pyramidon, whose chemical name is dimethylaminophenyl dimethyl pyrazolon, has been the favorite analgesic until very recently. Combined with a barbiturate (as in allonal) it brings relief from pain and insomnia in remarkably short order.

Just ten years ago there appeared in this country a new disease, granulopenia. It is characterized by the disappearance of the white corpuscles from the blood. Even a mild case leaves the patient extremely susceptible to disease, so that the victim of a common cold might suddenly and mysteriously die. The United States has averaged more than 400 fatal cases a year the past three years. The figures for France and particularly Germany, where amidopyrine was first introduced, run equally high. In England, on the other hand, where the use of this drug has never been favored, only *six* cases had been reported up to 1932. All circumstantial evidence so far collected points to amidopyrine as the guilty party. Manufacturers have, of course, not been required to label products containing amidopyrine specifically since the hazard attendant on its use has just become known. A recent number of the *Journal of the American Medical Association* warns purchasers of hypnotics and analgesics to inquire whether or not the drug desired contains amidopyrine. The use of amidopyrine, if permitted at all, should be restricted to patients having a white blood cell count several times a week. Anemic people are particularly warned against self-dosage with these drugs. Indeed, most people would do well to take analgesics and hypnotics only under direct order of their physicians. In fact, as a writer in a recent number of *Fortune* points out, even the barbiturates are by no means harmless. Under the physician's watchful eye they are safe as any drug can well be. The insomniac who requires the barbiturates to put him to sleep, finds himself growing accustomed to them and he must increase the amount he takes until finally he is playing with a fatal dose. The barbiturate "habit," if it may be called

that, even in mild cases brings in its train mental depression, lowered morale, and diminished physical efficiency. Extended use may even cause speech disturbances and loss of memory and judgment, among other evils.

For those not hypersensitive to it, aspirin would seem to be the only safe substitute for amidopyrine. Aspirin is also an analgesic antipyretic. It contains the benzene ring like the analgesics mentioned but no nitrogen. Unlike amidopyrine, aspirin may even temporarily increase the number of leukocytes, white corpuscles, in the blood. The indiscriminate use of aspirin is nevertheless fraught with danger. It may camouflage the progress of serious disease hindering timely correct diagnosis. Far too much aspirin is now in daily use throughout the world.

In the light of recent findings, it would seem that government control of the sale of these drugs has become a necessity. We need to be forcibly reminded that "drugs are good servants but bad masters." Unfortunately, only a few states regulate the sale of synthetic drugs. Official England has awakened to this need and the "battle of the barbiturates," as they call it, is on. Obviously the battle should cover the coal tar analgesic ground as well.

What can the chemist do to bring us out of the present dilemma? He must continue his research, making new substances until he finds the ideal hypnotic, the ideal analgesic, whose toxicities are minimal and whose curative powers maximal. Aware of the fact that there probably always will be some sufferers who insist on prescribing for themselves, the chemist must try to find drugs which will be as safe in the hands of the layman as the physician. He must continue to probe the secrets of the drugs occurring in nature and use the knowledge thus gained to create new drugs for the alleviation of suffering in its manifold forms.

ELEMENTARY SCIENCE IN IOWA

Miss Ferne Kratzer, teacher of Elementary Science in the Newton, Iowa Schools and a group of her 6th grade pupils broadcasted a Science lesson over station WHO in Des Moines recently. The lesson was on "Snakes of Iowa" with a real bull snake present.

Mr. B. C. Berg is Superintendent of Schools at Newton and for several years Elementary Science has been a part of the curriculum of the elementary schools. Miss Ferne Kratzer teaches Science to the pupils in grades 3, 4, 5 and 6 in the Lincoln Building. The Science room in this building has been especially equipped and arranged for science in the grades and is probably one of the very best of its kind in the United States.

TREES—"GIVE AND TAKE"

By Alice V. Bergstrom
Lyndale School, Minneapolis, Minnesota

We find this is pretty much the way of life. If you would "take" you must also "give." Likewise if you "give" you can hardly escape "receiving." So it is with our friends, the trees, which we have all about us so close and in such profusion that most of us know very little about them. Just a peep down the avenue that leads into the subject of trees makes us a bit more conscious of what they really mean to us.

The children in my room wished to learn something more about trees. The question they wanted to answer first was, "Are trees dead in winter?" About half of the children thought they were and the rest thought they were not dead. A discussion followed as to what we could do in order to find out. Twigs were brought in in March and placed in water. After several days signs of life began to appear in the form of enlarged buds. Finally blossoms formed on the box elder twig and soon green leaves appeared. On a willow twig even little rootlets began to grow. We planted these willows and they grew very well. Signs of life appeared on all but one branch and when we examined that one carefully, we found no sign of life. It broke very easily while the others could be bent a great deal without breaking. So our conclusion was that trees that are alive in the fall do not die in winter but only take a long rest, much as the bear does. Their food material is stored away for the growing season which is to follow. One little boy offered the information that trees couldn't be dead as nothing that is really dead ever comes to life again.

The children decided they wanted to make some scrap books and these books were to contain sections for the following subjects:

1. Tree parts
2. Trees we know
3. Kinds of trees of great importance in the world
4. Things we get from trees
5. Other uses of trees
6. Conservation
7. Tree poems
8. Tree stories
9. Music about trees
10. Pictures of trees

We drew a picture of a tree naming all the different parts This lead to a more intensive study of the tree parts. We discovered that the tree really consists of four distinct parts.

1. The trunk and branches
2. The leaves
3. The roots
4. The blossoms and fruit

Such questions were raised as, "How does the tree get woody?" "How does the tree grow?" "Why is the sap of the sugar maple sweet?" We found that buds grow into twigs. We measured new branches and found that one little branch grew three inches in one week in May. Years when there was plenty of rain the branches grew much longer than in the years when there was a lack of rain in the spring. This process of growing makes the tree taller, broader, and thicker. We found that each year's growth is shown in the cross section by a ring, and in this way we could count the number of years a tree has lived. As this growth proceeds the material in the tree becomes harder and forms the woody parts. But in order to grow, the tree must have food and we found that the leaves reach out to find air and light or sunshine, and that the roots absorb soil water. The leaves act as little factories using the sunlight to convert air and water into sugar which is the food of the trees.

They explained why maple sap is sweet. We found that sunshine is the power that runs the factory and when I asked, "How can you prove that sunshine really has power?" the children gave the following reasons as definite proof:

1. Sunshine puts tan on people.
2. Sunshine dries up streams.
3. Sunshine kills people by means of sun stroke.
4. Sunshine restores sick people to health.
5. It fades cloth paper, etc.
6. It burns grass, grain, etc.
7. It draws leaves toward itself.

As we proceeded to the roots we found that their purpose is to absorb the soil water containing dissolved minerals necessary for the growth of the tree, and also to act as an anchor to hold the tree in place. Finally we learned that the blossoms and fruit are a culmination of the other processes and work of the tree in order that the tree may reproduce itself and continue life in new trees. Innumerable questions were raised such as the following:

1. How do trees become petrified?

2. How old do trees become?
3. How did the first tree get started?
4. Why do trees need sap?
5. Do all trees have to grow in the sunlight?
6. How does the fruit get on the tree?
7. How does the pear get yellow and the apple red or green?
8. What makes the buds come where they do?
9. What makes the bark form?
10. What makes the trees have different shapes? (Pine—Elm)
11. Why are the leaves different shapes? (Oak—Basswood)
12. Why do some trees show signs of life before other trees do in the spring?

We took a walk around four blocks in our neighborhood and discovered that we had nineteen kinds of trees in this short distance.

1. Cottonwood
2. Elm
3. Poplar
4. Wild crab apple
5. Box elder
6. Birch
7. Apple
8. Willow
9. Catalpa
10. Juniper
11. Basswood
12. Pine
13. Spruce
14. Arbor vitae
15. Maple
16. Oak
17. Hackberry
18. Chokecherry
19. Mountain ash

We soon had a list of thirty-five kinds of trees in the world at large that we considered of really great value to mankind.

When we started to investigate the subject of products from trees, we were very soon impressed by the thought that man would have a very difficult time to even exist if it were not for trees.

We immediately experienced a feeling of gratitude and a desire to in some way repay this debt. We soon had a list of fifty-two important products that come from trees and help to make this world a better and happier place in which men may live.

When we approached our subject of "Other Uses of Trees" we found that not only men but also many animals are dependent upon trees for both food and shelter.

But now what can we do to repay this great debt to trees? Our answer seemed to come in our study of the subject of "Tree Conservation." In a short time we had eleven ways in which we can help the trees, such as:

1. Plant trees.
2. Do not cut a tree down unless necessary.
3. Water trees when it is too dry.
4. Do not break or cut small trees.
5. Protect trees from insect pests.
6. Tree surgery.
7. Protect trees from destructive animals.
8. Take care of fires.

9. Protect birds that eat insects.
10. Support ranger stations.
11. Protect trees from diseases.

We found a large number of poems and stories relating to trees. The children wanted to write some poems of their own about the trees, two of which follow:

TREES

Trees are very useful things,
Leaves grow on them in the spring,
Nests that are small and some that are big,
Resting there on every twig.

—By CYNTHIA HARDY

THE TREES

The birds in the trees sing so happy and gay,
They make me think of spring
And the beautiful trees with their colored leaves,
That shine so gay in the sun.

—By DON YEAGER

After our short sojourn with the trees I'm sure we all feel that if we will but give them a very small part of our attention, time and perhaps energy, as we move on in our too-hurried lives, they will repay us more than a hundred fold in a variety of services, happiness, and perhaps much-needed peace as—

The carpenter can build a house
With floors of birch or other wood,
And beams of oak and walls of pine
A shelter that is warm and good.

But carpenters cannot make trees
Or floors such as the forests know
Or halls like pathways through the woods,
For things like these must grow.

I like the shelter of a house,
But better, far, I love the trees
With trunks that stand against the wind
And leaves that whisper in the breeze.

In any subject, ability to deal only with the recondite and the abstruse and inability to answer the simplest and most natural enquiries is, to the shrewd observer, perhaps the simplest indication that something of real interest and importance still remains to be found out.—Soddy, *The Interpretation of the Atom.*

INTEGRATION OF SECONDARY-SCHOOL MATHEMATICS AND SCIENCE[1]

By E. R. Breslich

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Historical statement of the problem.—The problem of integrating mathematics and science is not new. As far back as thirty-five years ago plans have been suggested for establishing close relationships between the two fields. At that time it was hoped thereby to decrease or eliminate many of the difficulties encountered by the pupils in the study of mathematics and to attain more satisfactory results. Perry of England and Moore of the University of Chicago expressed the conviction that this could be brought about by placing greater emphasis in teaching on the practical application of mathematics, particularly by teaching mathematics in continual relation to problems of physics, chemistry and engineering.

The suggestions of these leaders were enthusiastically received by teachers of high-school mathematics and also by teachers of the high-school sciences. Historically the development of a great deal of mathematics grew out of the needs of the sciences. This fact made it seem logical that if some of the experiments usually performed in the science laboratory were performed in mathematics classes in such a way as to lead to discussions and formulations of the underlying mathematical problems and principles, the teaching of mathematics could thereby be greatly improved.

A striking indication of the widespread interest of the importance of the problem is the formation of the *Central Association of Science and Mathematics Teachers* with School Science and Mathematics as its official publication. One of the major purposes of the association was to find and establish legitimate contacts between the mathematical subjects and the sciences. It was hoped that the constant training which the pupil derives from applying mathematics to problems in science would increase his mathematical power and that his interest in mathematics would grow with the opportunities of using it in other school subjects. Indeed, some of the leaders of the movement were advocating that algebra, geometry and physics be organized into one coherent course. If possible this course was to be

[1] An address given at the Conference of Administrative Officers of Public and Private Schools, The University of Chicago, July, 1935.

taught by the same teacher or at least by two teachers who were in sympathy with the idea of correlation.

It must be admitted that these expectations have not been realized. The record shows that several committees have reported on ways of correlating science and mathematics, that the topic was discussed in the yearly meetings of the *Central Association of Science and Mathematics Teachers*, and that some progressive teachers and schools developed integrated courses which have been reported in School Science and Mathematics. Furthermore, writers of textbooks were quick to include among the verbal problems in algebra applications taken from the fields of physics and chemistry. Nevertheless, the movement did not gain widespread endorsement. It is significant that in 1923 the *National Committee on Mathematical Requirements*, which recommended several plans for a mathematical curriculum, failed to include in any of them suggestions as to the correlation of mathematics and science.

The foregoing historical sketch might give the impression that integration of science and mathematics is a closed issue and that it is no longer to be taken seriously as a plan of organization of materials. It is not intended to discourage interest in the plan. It does show, however, that great difficulties have to be overcome before success in the solution of the problem may be assured. The problem is much more difficult than that of the correlation of the various mathematical subjects. The soundness of that movement has never been questioned. Yet its progress has been very slow. Indeed, the movement might have failed had it not received new impetus from the junior high school movement, from the growing tendency toward integrated courses in the colleges, from the general educational movement toward integration of high-school subjects and comprehensive examinations, and recently from the College Entrance Examination Board.

It is possible that the causes contributing to the failures of the early attempts to integrate mathematics and science do not operate at the present time. The attempts were made during a period of high specialization and departmental organization when few teachers of mathematics were qualified to teach another subject. Furthermore, the plan of including among the verbal problems of algebra a number of exercises on applications to science failed because detailed explanations of the situations and of the new science concepts were usually lacking.

Thus, the science problems made little or no contribution to the teaching of mathematics. On the other hand, they actually added to the difficulty of algebra. The mathematical training derived from such problems was necessarily very small.

The mathematical needs of pupils taking courses in high-school science.—The extent to which high-school mathematics and science offer possibilities for integration may be seen from a number of studies that have been made during the last fifteen years. These studies were usually made by science teachers who undertook to determine the mathematics actually used in high-school physics and chemistry. The detailed findings of most of the studies have been reported in SCHOOL SCIENCE AND MATHEMATICS. As a rule the investigators employed the method of analyzing textbooks in physics and chemistry. They listed the mathematical processes and principles which they found. Other investigators went further and worked out all the problems that involved mathematical manipulation. Records were thus obtained of the specific operations and skills required of the pupils who were to solve the problems. A third method of obtaining the required information was to analyze the notebooks and other written work of the pupils.

The studies disclose two interesting facts. The mathematics involved in high-school physics and chemistry are of a much simpler type than most of the mathematics presented in courses in algebra and geometry, and all of the mathematics required in science are ordinarily taught in these courses. Anyone interested in the detailed findings may obtain them from the published reports of the investigators. For the present it is sufficient to summarize them briefly as arithmetical, algebraic, geometric, and trigonometric. Thus, a thorough knowledge of *arithmetic* is required. Since high schools, as a rule, do not and probably should not offer courses in arithmetical computation, responsibility for this type of training should rest with the science teachers fully as much as with the teacher of mathematics. Indeed, better opportunities for teaching arithmetic are offered in science courses than in the regular mathematics courses. The training in arithmetic should aim to develop: proficiency in the fundamental operations with integers, common fractions, and decimal fractions; knowledge of percentage; ability to use ratios and proportions; knowledge of the metric system and of other standard units of measure; ability to use and to interpret numerical tables; ability to employ the type of

reasoning used in solving verbal problems; and skill in solving such problems.

The *algebra* used in high-school science comprises ability to choose and employ good symbolic notation; ability to make substitutions in formulas, to evaluate formulas, and to solve formulas for specific required literal numbers; a knowledge of the laws of ratio and proportion; direct and inverse variation; logarithmic computation; signed numbers, and positive and negative exponents; ability to solve linear equations in one or two unknowns with integral or with fractional coefficients; ability to solve simple quadratic equations; ability to interpret relationships in formulas and equations; and ability to solve verbal problems by use of equations and formulas.

The methods of investigation make it impossible to discover the informational type. The pupil should be able to make simple diagrams and geometric drawings, including scale drawings; to read and interpret drawings; and to make and interpret graphs. A knowledge of the basic geometric concepts also is required. Acquaintance with the fundamental geometric constructions and with about a dozen geometric theorems is all the investigations disclosed.

The *trigonometry* of high-school science seems to consist of a knowledge of the meaning of the trigonometric ratios and of the fundamental identities by which they are related to each other.

Determination of the mathematics required in the science course in a particular school.—The foregoing summary of the studies aiming to determine the mathematics used in high-school science gives only an idea of what is *generally* required. Before an attempt is made to integrate the two subjects in a particular school a careful survey should be made of the mathematical needs in the specific science courses offered in the school. The method used by the department of mathematics of the University High School illustrates how this may be done. Mr. G. E. Hawkins, one of the instructors, has examined the materials of the physical science and chemistry courses and the problems assigned to the pupils. Each unit of the course was carefully analyzed and the required mathematical skills were recorded in the order in which they occur in the course and in the classroom. He listed typical problems and gave in each case the complete method of solution which was expected by the science teacher. The next step taken by the department was to study

his report to determine when and where contacts should be made in the two fields. Three examples taken from the study will indicate the type of analysis that is being made. The examples are taken from the unit on matter and energy.

1. *Problem:* If one allows $\frac{1}{2}\%$ for slippage on account of ice and snow, how many revolutions would the 80 cm. wheels of a car make in running a kilometer?

Solution: $$\frac{100,000}{80\pi}+.005\frac{100,000}{80\pi}=399.9=400.$$

It is evident that the solution of the problem involves many abilities, any one of which may decide success or failure. The pupil must be able to read the problem understandingly. He must grasp the situation described. He must know how to express measures. He must know how to express the number of revolutions in terms of circumference and distance traveled, i.e., the distance has to be divided by the circumference (80)(3.14). He must be able to multiply and divide decimal fractions. One-half per cent of the number of revolutions is to be found, and finally the two resulting decimal fractions have to be added. Thus, the problem involves arithmetical computation with whole numbers and decimal fractions; a knowledge of metric units, of the circumference formula, and of the relation between distance traveled and circumference. Moreover, ability in arithmetical reasoning is required to determine which arithmetic processes are to be performed and in which order. In this case it will be advantageous to add before dividing. Finally, the pupil must know how many figures to use in the value of π, how far to carry the multiplication by 80 and the division by 80π. Finally, his answer must be a reasonable one. Thus, an answer of 399.88 revolutions would pretend greater accuracy than is in keeping with the nature of the problem. The best he can say is that the wheels make about 400 revolutions.

Few teachers of science will take the trouble to identify the mathematical difficulties in this problem which at first thought may seem to be merely a simple arithmetical exercise. The chances are that if the pupils fail the teacher will dispose of the whole matter with the sweeping statement that the "pupils do not know how to use their mathematics." Problems of this type make integration highly desirable. Somebody has to see to it that the required abilities are developed. The problems supply the mathematics teacher with interesting applications and if

properly taught they offer excellent training in mathematical computation and thinking.

2. ***Problem:*** Find the resultant of two forces of 200 grams each acting at an angle of 60 degrees with each other. *Solution:* Draw to scale or construct a parallelogram with two adjacent sides equal to 200 units each forming an angle of 60 degrees. Draw the diagonal and measure it in the unit used for the sides.

The solution of this problem requires a knowledge of some of the properties of the parallelogram; of drawing an angle of 60 degrees either by use of protractor or by geometric construction; and of the use of ruler and squared paper in making scale drawings. The problem could be assigned to a class in plane geometry.

3. ***Problem:*** A captive balloon whose lifting force is a ton was blown during a storm until its anchor rope made an angle of 60 degrees with the surface of the earth. Find the force of the wind. *Solution:* The problem may be solved in three ways: by a scale drawing, by a proportion, or by trigonometry. The trigonometric method which is the most convenient is as follows:

A right triangle is drawn with the acute angle equal to 60°. The side opposite is 2000 and the side adjacent is the unknown, f.

$$\tan 60^\circ = \frac{2000}{f}$$

$$\therefore \quad f = \frac{2000}{\sqrt{3}} = 1154.7.$$

The force is 1155 pounds.

The solution involves the ability to make simple geometric diagrams; a knowledge of the tangent function; to find $\sqrt{3}$; to solve a simple equation; and to divide by a decimal fraction. The pupil must know how to express different measures of weight in the same unit. He must know to how many figures he should carry the arithmetical computations.

It will be noted that all of the skills and abilities which the three problems presuppose are contained in the general list derived from the studies mentioned earlier in this paper. The advantage of an analysis of the courses offered in a particular school is that it makes it possible to determine where the various processes and facts are needed in the science courses and where they may be taught in the mathematics courses. When that has been done the first step toward integration has been taken.

Attempts to solve the problem of mathematical difficulties in study of the sciences.—It has been shown that mathematical problems which occur in science courses and which seem simple at first thought involve serious mathematical difficulties. A detailed analysis of the abilities required to solve the problems would enable the teachers of both subjects to help the pupils overcome them. A detailed list of such problems would provide the teachers of mathematics with vital applications for the abstract facts and processes of mathematics. They offer excellent opportunities for bringing about a closer relationship between the two departments.

Ignorance in these matters has been the cause of criticisms of the teaching of mathematics and sometimes of friction between two departments that should be in the closest possible agreement. Indeed, one drastic recommendation for the solution of the problem of mathematical difficulties in high-school science has been to demathematize the science courses by making them essentially informational. Most science teachers, however, feel that the study of science is as much one of mathematical relationships as of accumulating a body of facts and information, and that high-school science courses freed from mathematics are not the best science preparation for pupils who expect to continue the study of science.

A second method of solving the problem of mathematical difficulties in science is to leave the science and mathematics courses undisturbed and to form two groups of students corresponding to their mathematical ability. Those who are able to make easy and rapid progress in mathematics are permitted to advance rapidly and with a considerable saving of time. The group of students less capable in mathematics is given some mathematical instruction. They finish the science courses at a slower rate of progress.

A third plan that has been tried in some schools is to administer to all students who enroll for courses in physics and chemistry an examination covering the mathematics needed in science courses. Usually the examination is given during the first week of the science course. The students who fail to pass the examination either do outside assigned work in mathematics along with the science course or they may postpone the science course until they are able to give evidence of possessing the required mathematical knowledge.

The three plans do not attempt a reorganization of courses

and involve only a small amount of cooperation between the two departments.

A fourth plan aims to reach an agreement between the departments as to which one is to assume responsibility for removing mathematical deficiencies. Either the students are referred to the mathematics department for correction of deficiencies when they appear, or the science teacher assumes the responsibility of teaching mathematics whenever such needs become apparent.

A fifth plan tries to establish complete departmental cooperation. The science situations requiring mathematical knowledge are determined. Each is analyzed as to the particular mathematical skills and processes involved. The mathematics department is informed as to the time when these skills and processes will be needed and undertakes to provide them.

The last plan has been modified in some schools by actually transferring certain science experiments of a mathematical nature to the mathematics department. This requires also the transfer of a certain amount of laboratory equipment. A few typical experiments which may be performed in the mathematical laboratory are: the relation between the metric system and other systems of measurement of length, area, volume, and weight; specific gravity; laws of leverage; law of vibration of the pendulum; center of gravity; images in the plane mirror, refraction of light; parallelogram of forces, composition and resolution of forces; the inclined plane, pulleys; development of certain formulas such as the relation of Centigrade and Fahrenheit; of distance and time in the law of falling bodies, and their graphical representation; curvature of a lens.

Experiments like the foregoing are based on mathematical principles and may be performed in the mathematical laboratory whenever these principles appear in the science courses. The plan suggests a type of integration which may be introduced in schools with little disturbance and difficulty.

Finally, a sixth plan has been advocated which recommends the merging of two departments into one. The same teacher gives instruction in science and in mathematics. The plan has been successfully used in European schools. Its introduction in American schools requires rather radical departmental changes which seem to make the plan prohibitive.

A modification of the plan was tried in the University High School during the past year. Since the mathematics and general

science courses alternate each semester in the seventh grade, one general science class was taught the first semester by one of the science instructors and continued with mathematics the second semester with the same instructor. Another group took mathematics the first semester and continued with general science the second, being taught the entire year by one of the mathematics instructors. Since not a great deal of mathematics is used in the general science course, there were few opportunities for integration. The major advantage was that the two instructors became thoroughly familiar with both fields and that each developed an acquaintance with certain problems peculiar to the other's field. One of the first steps toward closer cooperation between the two departments has thus been taken.

Summary.—It has been shown that the problem of integration of mathematics and science is not new. Professor Moore's recommendation made in 1903 "that algebra, geometry and physics of the secondary school should be organized into a thoroughly coherent course" sounds perfectly modern today, although it was made more than thirty years ago. For a number of years much interest was shown in the problem. A number of plans were advocated. However, these plans after being tried in various schools were abandoned and the problem received practically no more attention until recently.

The modern trend toward integration of high-school subjects has revived interest in the problem, and again certain progressive schools are experimenting. It is as yet too early to expect any measured results, and so far no results have been published that may be of assistance to other schools. However, the chances for success are more favorable, especially since most students now preparing to teach mathematics are qualified to teach courses in a second field. For mathematics this second field is usually in the sciences. Furthermore, the administrators of the secondary schools have become interested in the problem and are ready to encourage experimentation.

For schools planning to experiment with an integrated program in science and mathematics the following steps are recommended:

1. Analyze the science syllabus, texts, manuals, notebooks of pupils, guide sheets, and the specific units for situations which are mathematical in nature and require a knowledge of mathematical concepts, principles and processes.

2. Make a complete list of the types of mathematics which

pupils need to solve the science problems and to read understandingly the assigned literature.

3. Analyze the problems and reading matter to discover the specific abilities necessary for understanding.

4. Collect specific criticisms of the science department as to the mathematical deficiencies of the pupils.

5. Determine the place and time in which certain knowledge and skills are expected to have been acquired.

6. Check the findings against the mathematics courses to see if the requirements have been adequately provided for.

7. Hold joint conferences of the two departments to determine the mathematical responsibilities to be assumed by the science department and the science responsibilities to be assumed by the mathematics teachers. No progress can be expected unless both departments have a real interest in the plan.

8. Make arrangements for transfer of subject matter and experiments of science to mathematics, and of mathematics to be taught by the science teachers.

9. Encourage teachers of either department to offer courses in the other.

Advantages to be derived from the plan.—It is to be expected that the work of both departments will improve if science and mathematics are integrated because of the sympathetic attitude of all teachers toward the problems in both fields. The methods of the two departments will be in agreement and the pupil will not be confused by conflicting procedures employed by different departments. The plan should result in a saving of the pupils' time and effort. The chances are that the great scientific ideas and principles common to the two fields will really be learned by the pupil when he is given a broad outlook of both. The methods of science will find a way into mathematics teaching. Mathematics will tend to become more experimental and therefore less formal and mechanical—a study of relationships, a mode of thinking.

KENTUCKY WILDERNESS PRESERVATION

Kentucky's primeval wilderness, where Daniel Boone fought Indians and shot "b'ars," where Abraham Lincoln's parents struggled for a hard livelihood, has now almost disappeared, like wilderness areas everywhere in America. Preservation of what remains of this once almost continuous forest is the objective of a new organization, the Save-Kentucky's-Primeval-Forest-League.

FOILED BY LIGHT

A Pantomime for the Science Club

By H. R. Fisher

Sunbury High School, Sunbury, Ohio

The action of the bell is governed by a photoelectric cell (the Weston photronic cell is especially adapted to this) located in the knob of the safe. A cardboard safe is made or a safe front is merely painted on a cardboard and then draped so that it looks like a small safe. The cell is inserted through a hole in the knob which may be painted on the front. The cell is connected to a suitable relay (the Weston relay is excellent) which operates the bell located off stage. It should be a rather loud and shrill bell. The cell and relay are connected so that the relay switch closes the power circuit to the bell only when the light falling on the cell is interrupted.

The safe is located on the right of the stage. A desk and other pieces of furniture found in a man's private office are conveniently placed. Near the left side of the stage a small spot light is located so that it is concealed from the view of the audience but so that the beam of light from it falls on the cell in the knob of the safe. This light beam should be intense enough to hold the relay open but the relay should be adjusted so that the bell will ring as soon as the light is interrupted. The success of the action depends entirely on this. The entrance should be near the left. The light on the stage should be very dim but sufficient to show the actions of the burglar.

The text is to be read by a reader stationed off stage and the action of the character must be timed to the reading. At no time does the character utter any sound.

THE STORY

It was a dark and stormy night. The wind whistled and moaned through the pines and rain lashed the windows of the house that stood back in solitary dignity among the small forest of gloomy and dripping trees. It was a night when one was glad that he had no business that called him forth.

Inside all was quiet. The fire had burned out in the grate and the chill of the early morning hours was descending. In solitary silence a small steel safe in the master's den stood guard over the valuables of the family. A faithful safe it was. Not once had it been forced to yield up its treasure to the prying, the curious or the dishonest. Yes, a most faithful guardian of the family treasure. It was proud of this record of an unbroken trust.

Suddenly there is the scraping and squeak of a window being forced open. A foot comes over the sill, a leg follows and finally a man stands inside. A man short in stature and roughly dressed. A man with the catlike tread and black mask which label him as a member of that profession which makes its living,

not by honest labor, but as parasites on the efforts of the respectable members of society—a burglar.

With soft tread and furtive glances he moves about the room. He crosses the floor to examine a desk. With blood curdling clearness out of the darkness of the night a bell rings somewhere. Our friend with the mask freezes in his tracks. He listens, prepared for flight at the slightest sound. All is quiet so he decides it was only an alarm clock which went off by accident.

He resumes his explorations. He ransacks the desk but finds nothing of value. In disgust he throws papers on the floor. He had been told that Mr. X was a wealthy man and that he kept his valuables in his house. He is disgusted and mad. He crosses the room to continue his search. With fire alarm clearness again that bell peals forth. He is paralyzed with fear and with the quiet of a mouse stands poised for flight at the slightest indication of interference. There is none so he again resumes the search.

He spies the safe. Ah! success at last. Here is the object of his search. He exults and is already counting the money and fondling the pearls he will carry away. He is an expert with safes, a post graduate at opening any locked door. With overflowing confidence he approaches to make short work of forcing this safe to yield up its contents. He reaches for the knob when there is again that accursed bell ringing somewhere. He draws back and listens. All is quiet. He is nervous but can see no connection between his undesired presence and the bell.

Again he puts forth his hand to give the knob a few expert twirls. Again the metallic voice of the bell. Curse the thing what is the matter with it? Why does it have to ring just when he is about to try his hand on this little, old two-for-a-nickel safe?

A third time he tries the knob and a third time the bell shrills its warning. Surely it must be hoodooed. Surely there must be some connection between that hair raising bell and this dinky safe.

He wrinkles his brow and calls upon what few cells of gray matter he has to help him out of this hole. How could a safe ring a bell when a good honest man gets too close to it? Finally through the mists of memory there comes to him something he heard once. A guy told him they had contraptions that would ring a bell when light fell on them. Some kind of a cell. What a word! He remembered the last cell he had known. Didn't like

the bed and the steel walls were hard and unfriendly. But that didn't help him here.

Maybe the old geezer had one of these cells around this little one horse-power safe and it was ringing the bell. He scratches his head. No that isn't so for no light has been shown. He hasn't used a flash light. All poppycock then and a case of nerves. Why should he, Deadeye Dick, be bluffed by this little safe he could carry with one hand. Try it again and forget the bell. Can't be all night on this one job.

Again an experimental turn of the knob and again the bell bursts forth. Horrors, is he hearing things or is the place cuckoo. Must be something to this light cell business after all.

He casts about for an explanation and sees a tiny light shining across the room. Ah, here it is. This little light must have something to do with it. Sure, see how it shines right on the knob of the safe. Why didn't he think of that before. Any nit wit should have seen that as long as the light shone on the knob of the safe all was quiet. The knob must have one of those blasted cells built right into it. What a sap he had been not to think of that before. It took a smart man to think of protecting a safe that way and it also took a smart guy to figure out how to get around it. Just watch him. He'd show the old fossil he wasn't so clever after all.

Just shut this light off and, presto, then he could open the safe at leisure and thumb his nose at the fool cell in the knob. He contemplates smashing the light but decides it would be too messy. Why not just hang something over it so the light can't get out. Then all will be jake. He throws a table cover over the light and like the baying of a hound at midnight in the depths of a black forest the bell blares forth. He jerks the cover off and the bell stops. That's another good idea gone haywire. What is a guy going to do? He must give this a good think.

He considers and argues thus to himself: if I shut off the light the bell rings. If I try to turn the knob the bell rings. If I try to drill the lock I get in the light and the bell rings. If I try to smash the cell I get in the light and the bell rings. What is a guy to do?

Aw nerts. Might as well give it up. It sure is a hard life when an honest burglar can't open a dinky can like this just because a little crummy light is shining on it. These photoelectric cells sure make it hard on the profession. Blast the guy that in-

vented the thing anyway. Have to go someplace where they ain't so smart. To blazes with the smart guys anyway.

He thumbs his nose at the safe and leaves by the way that he came.

How could he know that the family of the house were away for the week end?

FOAM AS A FIRE EXTINGUISHER; A DEMONSTRATION EXPERIMENT

By Charles H. Stone
Boston, Massachusetts

The use of Foamite or Firefoam as an extinguisher of oil fires is well described and illustrated in our chemistry texts. The following demonstration is both interesting and convincing and is easily performed. Proceed as follows:

A. Making the trough. Procure a board four inches (10 cm.) wide and $\frac{1}{4}$ inch thick. Cut off a piece 9 inches (22.5 cm.); two pieces eight inches (20 cm.); and one piece four inches (10 cm.), in length. Screw the two eight inch pieces to the two sides of the nine inch piece, leaving a projection of one inch in the base board. Attach with screws the end piece between the ends of the two side pieces at the end of the trough where the base board projects. Inside the trough near the closed end, cut a circular hole just large enough so that a 200 ml. beaker can be easily inserted. The flare of the beaker will keep it from falling through; the pour-out should be directed toward the open end of the trough.

In the middle of the projecting end of the base board bore a hole the size of a ring-stand upright and close to the end piece. Near the top of the end piece and directly above the hole in the base board insert a long screw-eye. Support this apparatus on a ring-stand by thrusting the upright through the hole in the base board and through the screw-eye. The slope of the trough should be considerable; this may be regulated by turning the screw-eye in or out. Place the beaker in position.

B. Making the solutions. If your school has cans of material furnished by some of the Extinguisher Companies, follow the directions on the cans for making the solutions. In the absence of such material, the following may be used:

In 400 ml. hot water dissolve four grams of dry powdered glue. When completely dissolved, divide into two equal parts.

1. Dissolve in part 1, 20 grams sodium bicarbonate. Preserve in a stoppered bottle neatly labelled.

2. In part 2, dissolve 20 grams powdered alum or aluminum sulfate. Preserve in a neatly labelled stoppered bottle.

Fill two 50 ml. graduates from 1 and 2 respectively. Place below the lower end of the suspended trough a metal tray or large evaporating dish containing 100 ml. kerosene. Ignite the kerosene. You may be surprised at the difficulty of doing this; the kindling temperature of kerosene is fairly high. A little alcohol or other light inflammable liquid floated on the kerosene may make ignition easier.

When the kerosene is burning well, we may say that this represents a burning tank of oil in Oklahoma or elsewhere. Now pour into the beaker the contents of the two graduates, pouring them at the same time. The thick foam which forms will flow down the trough incline and fall upon the burning oil where it floats, spreading out to cover the entire surface of the oil. The flames are at once extinguished.

The unburned kerosene may be recovered by filtering through a DRY filter paper. The trough may, of course, be made of sheet metal at the tinsmith's. If made of wood, the under side of the baseboard at the open end should be protected by a square of asbestos tacked on.

The above experiment, properly performed with appropriate "patter" by the demonstrator adds a good deal of interest to the subject and makes the effectiveness of this type of fire-extinguishing material more realistic.

COLLEGE ENTRANCE EXAMINATIONS IN SCIENCE

The College Entrance Examination Board recently adopted the following resolutions:

That beginning in June 1937 examinations in botany, zoology, physical geography, and mechanical drawing be discontinued.

That during the next few years the Board make an intensive study of the effectiveness of examination procedures in biology, chemistry, and physics.

That in June 1937 the Board offer two new examinations, one in the field of the physical sciences including physics and chemistry and the other in the field of the biological sciences.

That as soon as expedient examinations in biology, chemistry, and physics be offered by the Board for those students who have passed beyond the second level and who are simultaneously offering four-year or Gamma mathematics as a part of their examination program.

BIOLOGICAL SCIENCE IN THE CHICAGO JUNIOR COLLEGES

By JEROME ISENBARGER
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The core of the curriculum of the Chicago junior colleges consists of the required survey courses, namely, English composition, one year; social science, two years; biological science, one year; physical science, one year; and humanities, one year. Traditional specialized courses are also offered as electives. The normal program of a student includes three three-hour survey courses and two electives.

The biological science survey is a lecture-demonstration course, required of all students. It may be taken in either the freshman or the sophomore year of the junior college.

The students in biological science meet for lectures in large classes three hours each week. The maximum number in each lecture group is limited only by the capacity of the science lecture room, which, in the case of Wright Junior College is 296. Each lecture class is divided into discussion groups of approximately 45 students which meet for one hour each week. The demonstration materials used in the lectures consist of drawings, diagrams, charts, lantern slides, and motion pictures. Opportunity is also offered for seeing and handling real materials in a demonstration room and museum which is open to all at specified times for the examination of microscopic and other preparations, museum materials, charts and living plants and animals.

The demonstration museum is in its formative period of development. It will require years to realize fully the possibilities of this feature of the course.

There was no precedent to follow in formulating this new course in biological science as our conditions are unique and our aims must necessarily be specific. The course was patterned to some extent after similar courses in the junior college organization of the University of Chicago and in the General College of the University of Minnesota. The theory of the course had as its origin the idea of general education and that the junior college training is, in reality, a continuation of secondary education.

The objectives of our students are extremely varied. In the case of a large number, school training will end with the termi-

nation of their work in our institution. Many others expect to continue their training in the university. We have students who are in our schools for their pre-legal training, many are pre-medics, and still others are receiving training in business. The greatest number are among the group taking work which would lead normally to the B.A. or B.S. degree. In response to popular demand, the colleges have introduced a secretarial course. Regardless of objective, all students take the biological science and other survey courses.

The previous school experience of our students in biological science represents every possible variety of background for the work in biology. All have had a course in general science in the first year of the high school. Some have had, in addition, a course of general biology in the second year, others have had a year of botany or zoology, and still others have had both botany and zoology in the high school. Quite a number have had no biological science training except that which they received in their work in general science. The students in the junior college may take biological science in their freshman year and their physical science in the sophomore year or vice versa, so approximately half of our students in biological science have a background of physical science and half have not had that training, except such as they may have had in high school.

The organization of the survey in biological science in the Chicago City Colleges is based on the belief that an understanding of a broad view of fundamental facts and principles of biology is vital in the life of every student regardless of the opportunities the student may or may not have to pursue studies beyond the work of the junior college. The problem of presenting the work to our conglomerate of membership without doing any violence to any one group has not been fully solved.

The aims of the course may be stated briefly as follows:

1. To give students a command of such biological information as is most closely related to their welfare as intelligent human beings.

2. To provide an opportunity to explore various fields of biological science as vocational and intellectual guidance.

3. To help students acquire the cause and effect relationship concept.

4. To give students a background of science which will enable them to appreciate and enjoy literature dealing with biological science.

5. To aid students in gaining an understanding of fundamental principles common to all living things.

6. To aid students in acquiring such knowledge of their own bodies and of their relation to the biological and physical environment as may be applied in the conservation of health and the development of physical and social efficiency.

It should be clearly understood that a lecture-demonstration course in biology can not attain all of the ends of education which a series of laboratory and discussion courses are intended to accomplish. Such claims presented to science teachers would be not only foolish but foolhardy as well.

Some of the claims made for laboratory work as stated by Cole[1] which can not be made for this course are as follows:

1. It furnishes a natural basis for learning through self-activity.

2. It provides for the development of laboratory techniques and manipulations in biology.

3. It provides in a concrete way for training in scientific method.

4. It provides a way of clarifying facts not easily understood without concrete illustration and verification.

5. It serves to develop in the student habits of inquiry, initiative, and careful work.

If we are honest with ourselves as teachers of biology, we shall have to admit that much violence has been done in the name of laboratory work, and that the aims fall far short of adequate realization in the case of large numbers of students who go through our laboratories.

In these days of restricted budgets it seems a wise policy to restrict the privileges and extend the advantages of training in laboratory techniques to those junior college students, only, who really desire it and who show a capacity for the work which gives promise of their being capable of benefiting from such training as the laboratory affords.

The exploratory functions are realized in that students who show unusual interest and aptitude, as judged by their work in the first semester of the survey, are permitted to elect a specialized laboratory course in botany or zoology which they may carry along with the second semester of the survey.

This feature has a positive side in that it may open to brilliant

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[1] Cole, *The Teaching of Biology*, pp. 94-95

students fields of possibility of which they would otherwise have no way of knowing. It also has a negative side in that it may serve to divert, early in their college course, inferior students who have cherished impractical dreams of a career in medicine or dentistry in which they could never succeed. In either case the student has been rendered a distinct service.

The most important feature of the organization of the survey course in biological science is its dynamic aspect. A syllabus can be adopted only as a temporary device to be used as a basis for experiment while its content is subjected to constant scrutiny and research by teachers who are in sympathy with the theory and aims of the course. The doctor's degree or equivalent has only relative importance as a qualification of the teacher who is to be entrusted to the work of determining the content of the syllabus or administering the course. The teacher must have not only a broad view of biological science but he must have as well a working knowledge of the basic sciences, chemistry and physics. It is the tendency of the specialist to place emphasis on technical detail rather than on general principles and facts which are significant in the life of the average student.

The content of the course is best considered in terms of learning units—comprehensive and significant aspects of the biological environment. Environment is considered in the broad sense as including not only the physical and biological surroundings, but also man's physical body as well.

Appropriate units and suitable topics under each may be stated as follows:

I. How the LIFE of the EARTH is MAINTAINED.
   Physical, chemical, and physiological characteristics of living matter.
   The cell as to structure and life processes.
   Tissues, organs, and systems.
   Energy relations of plants and animals.
   Cycle of metabolism of living things.

II. How ANIMAL and PLANT FORMS CHANGE in NATURE.
   Evidences of change and theories as to causes.
   Stages in the development of animal life and a survey of animal forms.
   Steps in the development of plants as related to the varied and changing environment.

III. The IMPROVEMENT of LIFE.
   Biological variation.
   Heredity.
   Methods of plant and animal breeding.
   Race improvement.

IV. Human Physiology and Hygiene.
Development of the human body.
Organs and systems.
Physiological processes.
Conditions necessary for proper functioning of body in health.

V. Contributions of Science in the Service of Health.
Discovery and application of scientific facts regarding foods, hormones and infectious diseases.
Immunity.
Anaphylaxis.

Student achievement is measured from time to time as the work progresses by the use of tests, principally of the objective type. At the completion of the year of biological science the students of the three junior colleges all take the same comprehensive examination prepared and administered by an examiner who devotes full time to the supervision and execution of the work of examinations in the surveys.

While the problems of the survey course have not all been solved they have been met and dealt with in a way that promises certain progress. The idea of general education offers opportunities for service which we are only beginning to appreciate. While educators have been busy in training leaders in biological science they have neglected the training of intelligent followers. The definite demand to-day for books and periodical writings in popular science seems to point to an awakened layman's interest. The demand is being met by a rapidly increasing body of material on science subjects which appeals because of the common sense method of attack in interpreting significant phases of the environment of the average person.

Leaders in biological science education who have been bewailing the fact that the social, cultural and philosophical possibilities of biological instruction have not been fully appreciated will do well to recognize the needs of the masses rather than those of the few who are specializing. The problem of place of science in education is primarily a problem of the secondary school, including the junior college, rather than a problem of the university. We shall always have a body of investigators interested in research. It is far more important just now that emphasis be placed on the need of a much larger group of educators necessary to develop in the masses understandings which will aid the largest number to appreciate the contributions of research toward the solution of the problems of every day living.

AN EXPERIMENTAL STUDY OF TWO PLANS OF SUPERVISED STUDY IN FIRST YEAR ALGEBRA

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The investigation reported here was planned and carried on in an effort to throw some light on the question of whether the long unit assignment plan of supervised study is superior to the divided period daily assignment plan. Two pairs of equated sections of ninth grade algebra at the Wauwatosa, Wisconsin, Junior High School were employed. One pair was made of superior boys and girls with I.Q.'s of from 105 to 131 (mean 115.6) and the other pair of average youngsters with I.Q.'s from 93 to 118 (mean 105.6).

The experimental variables. One of each of these pairs of sections was taught by use of large unit assignments covering on the average about two weeks. Mimeographed assignments and instruction sheets were distributed to each pupil. Two full class periods ordinarily were spent in discussing the material in the assignment. Instructions were given, questions were asked, explanations made, and demonstration work done on the blackboard. On the third day the pupils started to prepare the work of the assignment, and spent the entire period in supervised study. The teacher moved about the room from one pupil to another throughout the period giving assistance where it was deemed necessary. At the end of the period the assignment sheets together with all written work were collected to be redistributed the following day. This procedure was repeated each day until the stipulated time for the assignment had elapsed. At the end of each assignment period, a test was given covering the work of the unit and one period was given over for general remedial work before the new assignment sheets were passed out.

In each of the other sections each daily period was divided, the first half of the period was devoted to recitation, discussion and assignment activities, and the last half of the period to supervised study. The period division was carefully watched

and strictly adhered to throughout the experiment. No subdivisions were strictly followed in the recitation half of the period, but approximately two-thirds or twenty minutes of the period was given over to oral discussion, question and answer activity, and demonstration work leading up to the next assignment. The last ten minutes were quite definitely limited to the assignment and suggestions for procedure.

During the last thirty minutes of the period the pupils prepared the assignment given. The teacher spent the full time in passing from one pupil to another taking note of pupil progress and giving individual suggestion wherever it appeared necessary. Good order was maintained at all times, and wherever individual assistance was given it was done in a quiet tone of voice, not disturbing to the other pupils. All papers were collected at the end of the period whether the assignment had been completed or not. In most instances the assignment was completed. The teacher took particular care to limit the assignment to within the reach of all and added several additional problems in each case under the title of "extra credit" work which kept each individual occupied the full time.

Holding non-experimental variables constant. The pupils who were the subjects of the experiment in each pair of sections were so selected as to be of approximately equal mean ability and of approximately equal variability. In other words, the two sections of each pair were so made up to be of approximately equal means and standard deviations in chronological age, intelligence quotients (Otis Self Administering Tests of Mental Ability) and Standard Achievement Tests in Arithmetic, Form W as indicated below:

TABLE

DATA CONCERNING COMPARABILITY OF PAIRED SECTIONS

	Mean		*Standard Deviation*	
	Daily Assig.	*Large Unit*	*Daily Assig.*	*Large Unit*
Superior Pair				
Age	14.4	14.5	6.2	6.6
I.Q.	115.6	115.8	6.5	6.1
Arith.	104.0	103.8	5.7	5.8
Average Pair				
Age	14.8	14.7	6.8	5.6
I.Q.	105.6	105.6	5.9	5.5
Arith.	97.0	96.8	8.7	8.2

In pairing the sections boys were paired with boys and girls with girls, hence the two sections had the same proportion of each sex. No homework was assigned in either class. The same

teacher taught both sections. The same text was used by both sections.

No pupil was included in the experiment who was absent more than nine days. There was significant difference in the average absence of the paired sections. There was in effect a plan of make up work whereby students made up work missed during absence after school and absent pupils were not permitted to get behind.

The superior pair of sections met at 12:30 and 1:30 and the other pair at 8:30 and 10:30 A.M. If one section lost time due to fire drills, announcements or early dismissals, the papers were called in in the other section a few minutes earlier to correspond.

In every way efforts were made to hold everything constant except the experimental variables, namely, 'the plan of supervised study.

Measurement of results. As a means of measuring progress the Douglass Standard Survey Test was given at the beginning and at the end of the experimental period of a semester. The gains in scores on this test were taken as a measure of progress. The coefficient of reliability of this test was estimated by the chance-half Spearman-Brown technique to be .756 easily great enough to insure reliable measures of the mean or average ability of groups of this size.

Of the two superior sections the long unit group gained a total of 197 points to 170 by the daily divided period group, an average superiority per pupil of 1.1 points or 16%. This was 1.90 times the standard error of the difference which was .60, and the chances that it may be attributed to chance errors of sampling and measuring are only 3 in 100.

Of the two average sections, the daily divided period group had a slightly superior average gain per pupil of .42 points or 7%, only .95 times as great as the standard error of the difference and hence not statistically reliable since it may be attributed to chance errors, 17 times in 100.

When compared on the basis of the per cent gained of the amount of possible gain, the results were similar to those obtained by other methods, the long unit section being the superior of the two superior groups by 21.5 per cent and there being no significant difference between the two average sections, a slight but unreliable difference being found in favor of the daily recitation section.

These sections were tested again at the end of the second

semester during which they had been regrouped in various sections and taught by various teachers with various methods. There was no difference between the average scores of the two superior sections on the final second semester tests. Of the two average groups, the daily recitation method was superior by an insignificant amount only .21 of the standard error of the difference.

Conclusions. The type of large unit plan of supervised study employed by Mr. Stallard was found to be superior to his plan of daily recitation plan sections composed of superior pupils, though no significant difference was found between the two plans for sections of pupils of average ability. Until more complete evidence is available, presumption should be in favor of the long unit plan for superior pupils only.

These results are at slight variance only with the findings of other investigators, who with the exception of Hunziker, find results favorable to large units with average or representative as well as with superior pupils. Williams found with sections in second year algebra that a modified form of the Winnetka contract plan was superior. Hunziker found negligible differences in favor of larger unit assignments in algebra and definite differences in favor of daily units in geometry. Gadske found unmistakable favorable differences in favor of longer units in studies carried on with representative sections of first year algebra. Eilberg and Hare in geometry found the large unit method superior with representative groups. It is quite reasonable to give the large unit method the benefit of the doubt since few instructors have attained the relative degree of skill in its use that they have in the use of older methods.

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A PLANETARIUM NOT TOO TECHNICALLY CONSTRUCTED

By James H. Brayton
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"Astronomy is a grand subject, but if you see all the constellations during one course you are bound to lose a lot of sleep." So wailed the pupils in that subject in Manual Training High School. "The carrier boys for the earlier morning papers in clear winter weather might see some of the constellations, and report on them," said the teacher. But they didn't know what to look for nor where to find them.

So the class went to work to see what they could do about more information. The result of their mental and physical exertion was first a blue celestial sphere constructed in halves about three feet in diameter. There are conglomerations of odds and ends stored in the stock room of any high school science department. It's generally a mystery how they got there and what to do with them. But from these were shaped the instructional hemispheres. The ribs of stout wire, put together like the frame work of a huge umbrella, corresponded in location to the

hour circles on a star map or the meridians on a terrestrial globe. At the bottom of the hemisphere the ribs were attached with smaller wires and soldered to the circle which formed the sky's equator. The boys put in about forty boy-hours covering this framework with cheese cloth, then eight inch squares of wrapping paper, then adhesive paper strips and finally five or ten cents worth of Mr. Woolworth's sky blue paint. The girls marked off the hour circles (only every other one) which were then painted with show card white. The north star at the top and the ecliptic around half of the bottom with the more important constellations at their approximately proper declination and ascension were indicated by white stars of varying size to show magnitude.

But when this hemisphere was mounted over the demonstration table with a small globe underneath, it became too obvious that the stars were on the outside of the celestial sphere. Why not make the same design out of glass so that one could see the world revolving within, and get a view of what constellations were visible, say in China, when Americans were looking at Orion? Also: why not complete a southern celestial sphere since a glance at the real sky from South America was a very unlikely occurrence for most of us?

The result of such meditation was a determination to hang a false ceiling in the class room painted to represent the northern heavens. How to prevent prohibitive costs was the problem. In the wood shop we cut a sufficient number of pieces of two-by-twos to make four triangles, each of which was to represent one-fourth of the heavens. The base of these triangles had dimensions slightly less than the length and width of the room, and when completed, the points met at the north star which hung from the ceiling's center.

Across the street from the school is a paper company which donated several rolls of brown wrapping paper. These were tacked across the triangles, the strips being held together with adhesive tape. Then the drawing of the mythical figures which the ancients thought to reside in the sky was begun with black crayons. None of these figures was as simple as the layman's "big dipper," and their proper placement and drawing was a test of the class's ability. Once outlined, the background of the heavens was covered with some more of Woolworth's sky blue and the stars painted white and in proper magnitude. The home made planetarium was then mounted with an electric bulb

hanging through a hole in the top, representing the north star and furnishing illumination to the other stars at proper relative distances from it.

"The revolution of the earth and planets make different combinations in the sky and of course the most interesting ones always occur at 2.30 A.M.," complained one member of the class. "You will have to go to the Planetarium in Chicago if you want to see a representation of planetary revolution," said the teacher. "They have the equipment which we cannot hope to duplicate."

Not discouraged by this remark, one of the seniors in the class got to work on a telescope of the reflector type. He spent a couple of months working on things donated to him and finally completed a six inch telescope. It was made of two pieces of stove pipe mounted on a heavy wood frame. Twenty-seven hours were spent grinding the glass with carborundum and polishing it with rouge. The glass was silvered in the chemical laboratory. Then the class was able to see the real moons of Jupiter and other things which had not appeared on their planetarium.

MANY OF WORLD'S "CORAL" FORMATIONS WERE REALLY MADE BY SEAWEEDS

BY SCIENCE SERVICE

The "little coral workers" of the old-time Sunday-school rhyme have captured a lot of credit they never deserved. Not that they were to blame for it, the fault lay with human observers, who were prone to class as "coral" any limy formation that had a branching, plant-like growth.

Actually, a lot of this branching "coral" rock was made by real plants, Mr. Marshall A. Howe, director of the New York Botanical Garden, declared in a lecture. Many species of seaweed, especially the red algae, have the power to extract dissolved calcium salts from sea water and lay it down as part of their bodies. They do this even in the cooler seas of the world, whereas the stone-forming corals all grow in warmer water.

Examples of large limy formations of plant origin cited by Dr. Howe include great banks in the Arctic, beds and reefs in the Bahama and Bermuda regions, and near many tropical and subtropical islands in the Pacific and Indian oceans. In past times, great plant-lime reefs were formed in seas that are now dry land, and such limestone beds have yielded much building material for some of the world's most famous cities. Much of the building stone in Vienna, for example, comes from a plant-built limestone formation. There are also similar limestone reefs, not exploited commercially, in Wyoming and Montana, and in the Grand Canyon of Arizona.

THE EFFECT OF THE TIME FACTOR IN THE ADMINISTRATION OF TESTS

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In the final report (*American Physics Teacher*, Vol. 2, No. 3 Supplement, September, 1934), on the Cooperative Tests in Physics, which were given under the auspices of the American Council on Education in 1933–34, a statement is made to the effect that the ranking of students in physics courses by means of examinations is the same whether limited or unlimited time is allowed. This statement has been made by various persons who usually speak with authority but after diligent inquiry I have failed to locate any experimental basis whatsoever for such a statement.[1]

The teacher of physics uses tests for two distinct purposes: as a means of teaching the subject and as a means of ranking students for the purpose of reporting grades. He knows little about reliability coefficients, Pearson product-moment correlation or other tools used in scientific testing. The Cooperative Physics Tests[2] are used by teachers untrained in the educational methods of appraising tests and this paper is an informal presentation of the experience of one such teacher with them. It is not intended as a scientific contribution to the literature of testing, nor does it relate in the remotest degree to the reliability of the tests used. Various conclusions are incorporated which are justified by years of experience rather than by the data of this experiment. It is in answer to the question which is raised in the mind of many teachers on reading the postscript to so many test papers: "Time up. Could have answered more if time permitted." This study relates wholly to the problem of finding an answer to the practical question: Will each student earn the same grade when a limited as when an unlimited time allowance is made? Will a test be as valuable to the student as an instructional process when strictly limited to an hour as it would be if unlimited time were allowed in its study? One and only one conclusion is justified by this experimental data: Many students do not make the same letter grade on these

[1] Since this paper was written, Professor C. J. Lapp, of Iowa, has published under "Discussions and Correspondence," *American Physics Teacher*, 2, 1934, a report covering an experiment conducted with the cooperation of 16 students.

[2] Cooperative Test Service, American Council on Education.

standardized tests when on a limited time as they do when an unlimited time is allowed. This conclusion cannot be in the least affected by the characteristics of the tests themselves. The experiment deals with the practical question of the utilization of the information derived from the tests in the necessary process of reporting grades to a registrar. Complete information as to the reliability, the correlation coefficient and other technical characteristics of the tests used may be secured from the Cooperative Test Service, 500 West 116 St., New York.

The first and most obvious question is as to just how the scores derived from corrected test papers are employed in arriving at letter grades. A complete explanation of our own method will make a long story, but this discussion relates only to the results which would follow from the application of any of the usual methods of arriving at grades from scores derived from limited and unlimited time allowance tests. In this experiment the students were ranked in the numerical order of their scores. To the men making the highest scores were awarded A's. To those at the bottom of the column were given F's and D's. Intermediate grades came between these limits.

The following quotation from the *Iowa Manual of Directions of a Cooperative Test in Physics*, gives special importance to the "working time" of a student on a test: "Unless the test is made long enough to keep the best students busy working to the last minute, a serious injustice might result to the better students, since if it were made shorter, the better students would finish in less time than the poorer students and thus their scores would be based on a shorter working time than would the scores of the poorer students who would use the full time allowance."

The clear inference here is that if a test be given which even the best students cannot complete whithin the time allowed, then the number of questions answered in a limited time by any student may be taken to be a measure of the student's achievement in the study of physics. His rank depends on his capacity for "mass" or "quantity" production and, therefore, on the speed with which he is capable of working.

At Duke University, we have raised the additional question as to what ranking would result if unlimited time were to be allowed on a test which was so designed that the best student could not complete the test within the time limit originally set. We make greater use of tests as a process of instruction than as a means of grading students. Hence, with us deliberate thought

on a large number of questions has been found to be of much more value than high pressure effort in a limited time on a much more limited selection of questions. All test papers are invariably marked with care and discussed with the students before their keen interest in them dies out.

Our local conditions are in some respects quite favorable. Here, all sections of certain large first year college courses are given the same test at the same hour, either in the afternoon or in the evening. It is easy for us, therefore, either to terminate the test at the end of a set period, say fifty minutes, or to allow it to continue as long as the student desires to work. In the progress of this investigation, which has been carried on at intervals for over two years, we have used our own tests of an objective type, the Iowa tests,[3] and the Cooperative Test Service tests,[4] and have collected about a thousand papers. Tests of our own authorship are invariably first taken by members of the staff and are so constructed that each test is completed in 45 minutes or less. Tests start usually at 3 P.M. and one proctor is provided for every 30 students. On some tests the student is given colored pencils with the examination paper with which to score until the set time limit has expired. On other tests he is requested to circle the number of any question answered after the time limit specified. Should an answer be corrected after the time limit allowed, it is counted as having been answered outside the limit. After the papers are graded, the students are ranked in two ways—first, by arranging in order of magnitude the limited time scores on a given test and then, in a parallel column, the scores made in unlimited time on the same test. In this way, so far, we have analyzed the achievement of about one thousand students, have accumulated a large amount of evidence, but, as yet, we have not hit upon a very satisfactory method of correlating it so as to make an adequate exhibit of the result obtained for purposes of publication. To conserve space I here report five types of observations on two of the Cooperative Test Service tests. The students in each of these tests were arranged in the two columns described above and the information derived is tabulated below. The results of no one of the various tests used differ widely from the two selected here.

The ranking of students by the scores earned when the time limit specified was enforced is denoted by (I).

[3] C. J. Lapp, University of Iowa, Iowa City.
[4] Cooperative Test Service, 500 West 116 St., New York City

The ranking of students on the same test when the time limit was not enforced and unlimited time allowed is denoted by (II).

	Sound	*Mechanics*
Number of students making "A" by both (I) and (II)	15	14
Number of students making "A" by either (I) or (II) but not by both	21	26
Number of students making "F" by both (I) and (II)	22	30
Number whose positions in each column differs by as much as 11 points	22	30
Number of students making "F" by either (I) or (II) but not by both	111	123
Number of students whose rank is the same in both columns	8	8

In the analysis of the Cooperative Test on Sound there were 244 cases. The name at the top of the time limited column (I) was 14th from the top of the unlimited time column (II). The 25th and the 61st from the top of column I were also the 25th and the 61st from the top of column II. The student who was 35th from the top on the restricted time column I was 2nd from the top of the unlimited time column II. Such deviations are quite numerous.

The Fall Term final examination (1934) was a National Cooperative Test and the time limit prescribed was enforced. The class grades were again arranged in two columns. In one column was exhibited the distribution of the total daily scores up to January 19th. In another column was exhibited the distribution of grades made on the examination (Restricted Time). Out of a section of 69 men the letter grades of 37 as determined by the Final were different from that determined by the term average. The inescapable conclusion of all our observations involving a large number of tests is that a student may not make the same letter grade on limited and on unlimited time tests. Numerous instances are discovered in which a student earns a "B" on unlimited time and makes an "A" on limited time tests. Equally numerous are instances in which a student makes "A" on unlimited time but in the limited time will rate as low as "C."

Numerous instances are also noted in which a student fails on limited time and passes on unlimited time and vice versa.

We would not feel justified in using a method of ranking students which would fail even a few students, and force them to repeat the course, merely because of their lack of speed, or which would give an A to a student largely because of his speed. It is desirable to train students in speed but that is not a proper objective in either a mid-semester or a final test. Other more frequent and more appropriate occasions should be chosen for such training. Nothing should be allowed to obscure the results of a test and thus to give students inaccurate rank.

The statement quoted above from the "Manual of Directions" is unquestionably correct for the conditions contemplated, but a more accurate ranking of students according to achievement—and not according to ability—is secured when questions are used which have been carefully graduated as to difficulty and when every student is allowed all the time he desires. It is then not at all a question of speed but of knowledge and of ability to reason. When students are instructed to pick the easy questions first, then, within the time limit set, a majority of the students fill up their available time with easy questions and never reach the questions that challenge them. If a question is not answered or a problem is not worked on an unlimited time test, then we know that it was omitted because the student was unable to answer it.

It is a matter of common observation that one man can pick up a book and in a few minutes grasp the essentials of an assignment. Another may work on it for a long time and achieve a greater and more permanent mastery of the subject matter. One student may become nervous and confused when forced to work in the utmost haste, while another suffers no such unfavorable reactions. I do not think that many teachers of physics wish to test their students' quickness of perception, speed in performance or even innate ability to reason accurately from given facts. Such tests are a check up on Nature's skill in making men. Such a check up is probably best made by psychological tests in which no physics questions are involved. Certainly no physics teacher wishes to have a student repeat a course when, merely because of his slowness, he does not perform in a limited time as creditably as does his fast neighbor.

No one realizes better than I the inherent difficulties and uncertainties involved in educational measurements. Too many intangibles enter into this experiment. It is impossible, for instance, for a large group of students to take an examination with

a time limit set, say, of fifty minutes, and then in the same mood take the exact equivalent of it covering the same subject matter at a leisurely pace with no time limit enforced. It is practically impossible for any one to frame two tests on the same subject matter which is certain to be of equal difficulty to the lower level student. It is also impossible to make a comparison of the showing of a student on a time limited test covering one portion of a text with his performance on an unlimited time test on quite another portion of the text. There are too many uncontrolled factors involved. Should one allow a student to answer all the questions possible under the impression that the time limit set will be enforced and then, at the end, allow him to complete the test, we still have no adequate means of comparing his performance on a limited with that of an unlimited time test. We have obviously introduced at least several of the objections raised to working in haste—the nervousness, the confusion of ideas and other distractions—into the first part of the test. On the other hand, should the student know in the beginning that his record will be determined by the unlimited time test performance, we may be fairly sure, in spite of all our exhortations, that some students will not accomplish as much in the first hour as they would have accomplished had they known that longer time would not be allowed. It is a common observation that many students dally over their work—their minds wander. We all appreciate the difficulty encountered in securing the whole-hearted cooperation of any large group.

The limited time test has proved unsatisfactory to a large number of our students. At the end of last year in which the class had taken a number of tests with both the limited and the unlimited time allowance, a vote was taken to determine the class preference. Out of a group of 234, 223 expressed a preference for unlimited time on their tests. Whether justified or not, it is a fact that many students are not convinced that they are being fairly judged by a test when they realize that they could have answered a number of additional questions had time permitted. The test seems unreasonably long for the time allowed and when this idea spreads, an unfavorable reaction against the course results among the students and for an entirely elective course this leads to unfortunate results. Within reasonable limits the longer the test and the longer the time allowed the student to study the test, the more valuable it is as an instructional process. It is unfortunate that it should be disconcerting

and perhaps discouraging to a student to realize after a year's study, what a large fraction of the subject matter of a course he has not mastered. But only on such a true self analysis can a successful career as a student of physics be built.

ON STRUYK'S "DIOPHANTINE RECREATIONS"

By HOWARD D. GROSSMAN
De Witt Clinton High School, Bronx, New York

Adrian Struyk's "Diophantine Recreations" in SCHOOL SCIENCE AND MATHEMATICS of March 1935 permits of an interesting extension. As he himself points out at the end of his paper, if $f(x) \equiv (a-1)x^2 - ax - (a+1)$ is factorable, then $5a^2 - 4 =$ square, say b^2, or $b^2 - 5a^2 = -4$.

(Conversely if $b^2 - 5a^2 = -4$, then $f(x)$ is factorable. Moreover the factors have integral coefficients. PROOF: If n/m and s/r are the (necessarily rational) roots in their lowest terms of $f(x) = 0$, then $\phi(x) = (mx - n)(rx - s)$ has relatively prime coefficients, since any prime factor of $\phi(x)$ divides either $mx - n$ or $rx - s$. Since $f(x)$ also has relatively prime coefficients, $f(x) \equiv \phi(x)$.)

The positive solutions of $b^2 - 5a^2 = \pm 4$ in order of increasing magnitude are given by the table:

$b = 1, 3, 4, 7, 11, 18, 29, 47, 76, 123, 199, 322, 521, 843, 1364, 2207, 3571, \cdots$
$a = 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, \cdots$

This table may be deduced from Pell Equation theory. The number-pairs in the 1st, 3rd, 5th, $\cdots$ columns are solutions of $b^2 - 5a^2 = -4$; those in the 2nd, 4th, 6th, $\cdots$ columns are solutions of $b^2 - 5a^2 = 4$. The numbers in the lower row are those of the well-known Fibonacci series in which each number is obtained by adding the two preceding ones after setting down 1, 1. Those in the upper row are obtained in the same way after setting down 1, 3. Alternate a's, beginning with the third (the first makes $f(x)$ linear), make $f(x)$ factorable.

If the successive a's are called $a_1, a_2, \cdots$, Struyk's recursion formula here becomes $a_{n+2} = 3a_n - a_{n-2}$.

PROOF: $a_{n+2} = a_{n+1} + a_n = 2a_n + a_{n-1} = 3a_{n-1} + 2a_{n-2} = 3(a_{n-1} + a_{n-2}) - a_{n-2}$
$= 3a_n - a_{n-2}$.

It may be further proved that $a_{n+4} = 7a_n - a_{n-4}$,
$a_{n+6} = 18a_n - a_{n-6}$,
and in general that $a_{n+2k} = b_{2k}a_n - a_{n-2k}$
and $b_{n+2k} = b_{2k}b_n - b_{n-2k}$.
Still more generally $a_{n+k} = b_k a_n - (-1)^k a_{n-k}$
and $b_{n+k} = b_k b_n - (-1)^k b_{n-k}$.

These include the original formulas from which they are derived: $a_{n+1} = a_n + a_{n-1}$ and $b_{n+1} = b_n + b_{n-1}$. (We may add at the beginning of the table the trivial solution $b_0 = 2$, $a_0 = 0$.)

Only in human affairs, in economics, do we deceive ourselves into believing in compound interest—with the resulting depressions and wars. —John A. Eldrige, *The Physical Basis of Things.*

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1406. *Proposed by Maxwell Reade, Brooklyn.*

(1). Arrange five fours in such a way that the result is 55.

(2). Arrange eight eights in order to get 1000.

The following solutions were offered:

(1) $\dfrac{44}{4}\times\dfrac{\sqrt{4}}{.4}=\dfrac{44}{4}+44=55.$

(2) $$888+88+8+8+8=\frac{8}{.8}\times\frac{8}{.8}\times\frac{8}{.8}\times\frac{8}{.8}=\frac{8888-888}{8}=\frac{8\left(8+\dfrac{8+8}{8}\right)\dfrac{8}{.8}}{.8}$$

$$=888+\frac{888+8}{8}=8\left[8(8+8)-\frac{8+8+8}{8}\right]$$

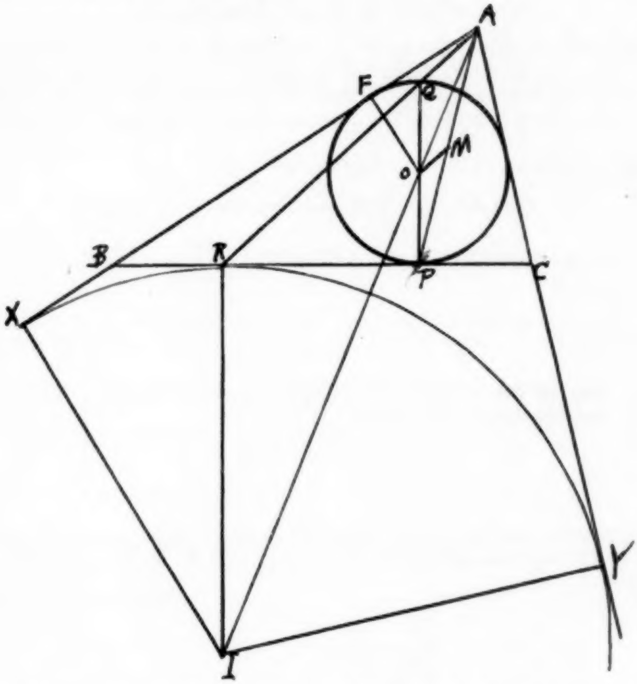
$$=8\times 8(8+8)-8-8-8=(8\times 8\times 8-8)\ \frac{8+8}{8}-8$$

$$=\frac{8888}{8.888}=\frac{88}{.88}\times\frac{88}{.88}=1000.$$

Solutions were offered by Harvey Bullis, Rapid City, S. D., John N. Meighan, Harper's Ferry, W. Va., Hyman Zalosh, New York, H. G. Ayre, Waukegan, Illinois, W. E. Buker, Leetsdale, Pennsylvania, J. Lee Hart, Jr., Kalamazoo, Michigan, Maxwell Reade, Brooklyn, Norman Anning, University of Michigan, Charles W. Trigg, Los Angeles, Bernard Sherak, Brooklyn, Carl Jensen, Kirksville, Missouri, Charles C. D'Amico, Albion, N. Y., Jerry Roberts, Port Arthur, Texas, and Margaret Joseph, Milwaukee, Wisconsin.

1407. *Proposed by Walter H. Carnahan, Indianapolis.*

A circle is inscribed in triangle ABC and touches BC at P. Prove that the line drawn from the midpoint of AP to the midpoint of BC passes through the center of the circle. The following solution was offered by F. A. Cadwell, St. Paul, Minnesota.



Let O be the center of the inscribed circle and M the midpoint of AP. Draw MO. Draw the circle, center I, touching BC at R and AB and AC respectively at X and Y. Draw the diameter PQ of the inscribed circle. Let F be the point of contact of the inscribed circle with AB. Draw AI, which will pass through O. Draw OF, IX and IR.

The triangles AOF and AIX are similar. Hence

$$\frac{AO}{OF}=\frac{AI}{IX},\quad QO=OF \text{ and } IR=IX. \text{ Then}$$

$$\frac{AO}{OQ}=\frac{AI}{IR}$$ and since OQ is parallel to IR, A, Q, and R are collinear.

$AX=AY=S$ (half perimeter of ABC).

(1) $BX=BR=S-AB$. But $2\ (PC+AF+BF)=2\ (PC+AB)=2S$. Hence

(2) $PC=S-AB$. From (1) and (2) $BR=PC$.

Since M is the midpoint of AP and O is the midpoint of PQ, MO if produced will meet BC at the midpoint of RP. But the midpoint of RP coincides with the midpoint of BC, since $BR=PC$.

Therefore the line drawn from the midpoint of AP to the midpoint of BC passes through the center of the inscribed circle.

A solution was also offer by H. R. Haynes, Tacoma, Washington.

1408. *Proposed by H. D. Grossman, New York.*

Through a given point between the sides of a given angle draw a line cutting off a triangle of given area.

Solution by W. E. Buker, Leetsdale, Pa.

Let the angle be PAQ the point C, and the given area A. Suppose the required triangle is AEF, E and F being on AP and AQ, respectively. Draw CD parallel to AP, and CG and ED perpendicular to AQ. Call the known values of CB and AD, b and a, respectively and the unknown AF, x.

Triangles AFE and GFC are similar, so

$$GF:AF::BC:ED, \text{ that is } x-a:x::b:ED$$

Hence: ED equals $(bx)/(x-a)$ and $A=\frac{1}{2}x(EG)=\dfrac{bx^2}{2(x-a)}$.

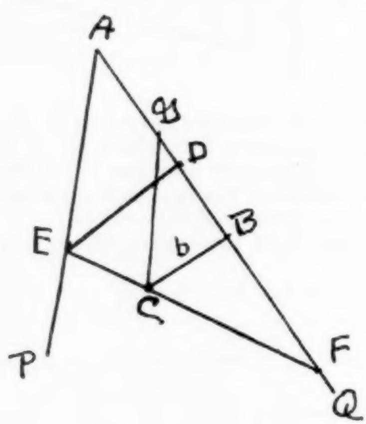
Solving for x, $x=\dfrac{A\pm\sqrt{A^2-aAb}}{b}$.

Thus x may be constructed. There may be two solutions.

If C is outside PAQ, GF equals $x+a$, and

$$x=\frac{(A\pm\sqrt{A^2+Aab})}{b}.$$

Solutions were also offered by Maxwell Reade, Brooklyn, Julius Freilich, Brooklyn, Hyman Zalosh, New York City, and A. R. Haynes, Tacoma.



1409. Evaluate $\sum \dfrac{x^2 4^x}{(x+1)(x+2)}$.

Solution by Charles W. Trigg, Cumnock College, Los Angeles

$$\frac{x^2\cdot 4^x}{(x+1)(x+2)}=4^x\left(\frac{x^2}{x+1}-\frac{x^2}{x+2}\right)$$

$$=4^x\left[x-1+\frac{1}{x+1}-\left(x-2+\frac{4}{x+2}\right)\right]$$

$$=4^x\left(1+\frac{1}{x+1}-\frac{4}{x+2}\right). \text{ Hence,}$$

$$\sum_1^n \frac{x^2\cdot 4^x}{(x+1)(x+2)}=\sum_1^n 4^x+\sum_1^n \frac{4^x}{x+1}-\sum_1^n \frac{4^{x+1}}{x+2}$$

$$=\sum_1^n 4^x+\left(\sum_1^n \frac{4^x}{x+1}-\sum_2^{n+1} \frac{4^x}{x+1}\right)$$

$$=\frac{4(4^n-1)}{4-1}+\left(\frac{4}{2}-\frac{4^{n+1}}{n+2}\right)$$

$$=\frac{4^{n+1}}{3}-\frac{4}{3}+2-\frac{4^{n+1}}{n+2}$$

$$=\frac{(n-1)4^{n+1}}{3(n+2)}+\frac{2}{3}.$$

Solutions were also offered by J. Lee Hart, Jr., Kalamazoo, Michigan, and John Meighan, Harper's Ferry, W. Va.

1410. *Proposed by Richard A. Miller, University of Iowa.*

Prove: $\log_e (1+3x)^{(1+3x)/6}\cdot(1-3x)^{(1-3x)/6}=\frac{3}{2}x^2+\frac{9}{4}x^4+\frac{81}{10}x^6+\cdots.$

Solution by Lester Dawson, Wichita, Kan.

$$\log_e (1+3x)^{(1+3x)/6}\cdot(1-3x)^{(1-3x)/6}=\frac{(1+3x)}{6}\log_e(1+3x)+\frac{(1-3x)}{6}\log_e(1-3x).$$

By MacLaurin's series,

$$f(x)=f(0)+f'(0)\frac{x}{1!}+f''(0)\frac{x^2}{2!}+\cdots+f^{(n)}(0)\frac{x^n}{n!},$$

We expand:

$$\frac{(1+ax)}{6}\log_e(1+ax)=\frac{ax}{6}+\frac{a^2x^2}{12}-\frac{a^3x^3}{36}+\frac{a^4x^4}{72}-\frac{a^5x^5}{20}+\frac{a^6x^6}{180}-\cdots.$$

Letting $a=3$ and $a=-3$, we obtain:

$$\frac{(1+3x)}{6}\log_e(1+3x)=\frac{x}{2}+\frac{3}{4}x^2-\frac{3}{4}x^3+\frac{9}{8}x^4-\frac{243}{20}x^5+\frac{81}{20}x^6-\cdots. \quad (1)$$

$$\frac{(1-3x)}{6}\log_e(1-3x)=-\frac{x}{2}+\frac{3}{4}x^2+\frac{3}{4}x^3+\frac{9}{8}x^4+\frac{243}{20}x^5+\frac{81}{20}x^6+\cdots. \quad (2)$$

Add equations (1) and (2) to get:

$$\log_e (1+3x)^{(1+3x)/6}\cdot(1-3x)^{(1-3x)/6}=\frac{3}{2}x^2+\frac{9}{4}x^4+\frac{81}{10}x^6+\cdots.$$

Solutions were also offered by Charles W. Trigg, John N. Meighan and the proposer.

1411. *Proposed by William F. H. Godson, Jr., Norwood, Pa.*

Construct the two tangents from a point to a circle without drawing any arcs, i.e., by means of straight edges only.

Solution by H. G. Ayre, Waukegan, Illinois

Given: Circle O with point P outside the circle.

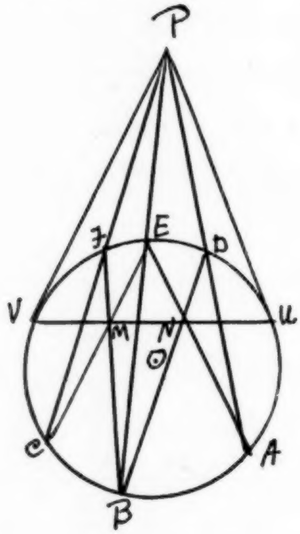
To Construct: Tangents PU and PV.

Construction: From point P draw any three secants such as PDA, PEB, and PFC. Draw lines AE, DB, EC, and FB. Through the points of intersection M and N draw line UV. U and V are the points of tangency. Therefore the required tangents are PU and PV.

The proof depends upon facts from modern geometry. The line UV is the polar of point P which is the cord of contact of tangents drawn to the circle from P.

Note: It is interesting to observe that this method is applicable to any conic and furthermore it is not necessary to know the center of the conic. If Lemoine's test for simplicity is applied it is found that this method yields a simplicity which is less than that found by Euclid's method of using straight edge and compasses when the center of the circle is unknown.

Solutions were also offered by Kenneth Kidd, Sweetwater, Tennessee, W. E. Buker, Leetsdale, Pa., R. A. Miller, Iowa City, Iowa, Charles C. D'Amico, Albion, N. Y., and the proposer.



HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1406. Martha Strickland and Robert Nicoll, Hamilton High School, Elmsford, N. Y., Polo (Ill.) Community High School Math Club. Sycamore (Ill.) Adv. High School Class; Sarah Crane, Walter Lansen and Christy Kuemmerle from Leetsdale (Pa.) High School.

PROBLEMS FOR SOLUTION

1424. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

A cylindrical glass tumbler, 3" in diameter and 6" high is half filled with water. If the glass is $\frac{1}{8}$" thick, to what angle with the horizontal may it be tipped without spilling any water?

1425. *Proposed by George Lunsk, Philadelphia.*

Two trains 200 feet long and 152 feet long are running at uniform rates on parallel tracks. They pass each other in 3 seconds when running in opposite directions and in 12 seconds when going in the same direction. Find the rate of each train.

1426. *Proposed by Norman Anning, University of Michigan.*

Show that for n, a positive integer, $x^n - nx + (n-1)$ is divisible by $(x-1)^2$.

1427. *Proposed by W. E. Buker, Leetsdale, Pa.*

Show how to draw within a triangle three circles, each of which shall be tangent to the other two circles and also to two sides of the triangle.

1428. *Proposed by F. A. Cadwell, St. Paul.*

If $a+b+c=d+e+f$, and $a+d=b+c=c+f$, prove that $a^2+b^2+c^2 = d^2+e^2+f^2$.

1429. *Proposed by Lester Dawson, Wichita, Kansas.*

Arrange the digits 0 1 2 3 4 5 6 7 8 9 so as to give 100 as in 89 3/6+10 27/54=100.

Note:—Problems 1402 and 1413 are identical. The Editor regrets the error on his part.—Editor.

COSMIC RAYS AID STUDY OF MAGNETISM

Cosmic rays, no longer the mystery they once were, are now used as highly valuable working tools in the scientific laboratory. Their newest use is to help investigate the nature of magnetic forces inside a magnet, according to papers presented before the meeting of the American Physical Society at Baltimore.

The nature of such internal magnetic forces has been almost impossible to investigate hitherto. Scientists could easily study the forces outside the magnet with great precision, but what was happening inside the magnet remained a mystery.

High speed and piercing cosmic ray particles, however, are capable of passing right through great thicknesses of iron. By seeing how much their paths are bent in going through the magnet, physicists are now able to acquire knowledge of the magnetic field strength in the magnet's interior.

The technique is similar to the way one might estimate the force of a hurricane storm by the extent to which a ship has been driven off its course.

Two reports describing the theory and experimental studies were presented to the Society by Prof. W. F. G. Swann of Bartol Research Foundation and his colleague, Dr. W. E. Danforth.—*Science Service.*

SCIENCE QUESTIONS

January, 1936

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

TELL ME, PLEASE! How can I have an interesting and good "Science Questions," unless YOU SEND ME THE MATERIAL?

Just address Jones, 10109 Wilbur Ave. S. E. Cleveland, Ohio.

Thanks!

RADIATOR ANTI-FREEZE

730. *What do you use and why?*

a. "My daughter's car is a Terraplane. I think she should put in about 2 gallons of Methanol." What's wrong, if anything, with this statement?

b. One distributor puts out an anti-freeze which is labelled "Sentinel Anti-Freeze Methanol—Poison—Contains over 15% Methanol (Methyl Alcohol—Wood Alcohol)." What is the other 85%? Water? or Grain Alcohol? They say it is 190 proof. Are their statements correct?

c. What is Methanol? Is it anything but Wood Alcohol? Is it violet in color, or is it artificially colored? Does it contain an anti-rust compound?

d. "Zerone" carries a label—"90% Methanol" and they charge $1.00 a gallon. Sinclair's Anti-freeze carries a label—"75% Methanol"—cost 80 cents a gallon. Which is cheaper?

ONE SLEUTH TO ANOTHER

731. *Proposed by "Al" Hawkinson (Elected to GQRA, No 114), Weston Avenue, Niagara Falls, N. Y.*

A gas company in London was being defrauded by a customer in whose apartment a "shilling" meter was installed. (In a "shilling" meter the customer deposits a shilling and can use gas up to a shilling in value.) The gas company was sure that the customer was using more gas than he was paying for but were unable to detect the manner of fraud.

Finally, they went to him, assured him that they knew he was stealing gas, and finally offered to give him free gas for a year if he would tell how he carried on the fraud.

The customer was clerk at a soda water shop.

How did he defraud the gas company?

NUT NUMBER FIFTY

732. *Proposed by I. N. Warner (GQRA, No 56). (Selected from his "58 Nuts to Crack.") Incidentally does Archimedes' solution show that he knew Algebra?*

Hiero, the King of Syracuse, gave his goldsmith 14 lb. of gold and $3\frac{1}{2}$ lb. of silver with which to make a crown for the King. The goldsmith finally got a crown made, of weight $17\frac{1}{2}$ lb. and delivered it to the King. Hiero, however, suspected that the goldsmith had put in too much silver and too little gold. So he gave the crown into the hands of the philosopher, Archimedes, to determine, if possible, the exact truth about the two metals in the crown. By experiments, Archimedes discovered that the specific gravity

of gold alone is $19\frac{1}{4}$ and the specific gravity of silver is $10\frac{1}{2}$, while the specific gravity of the crown was only $14\frac{5}{8}$.

What, then, wete the real weights of gold and of silver in the crown?

DIVIDE THIS UP

733. *Proposed by Arthur L. Hill, Peru State Teachers College, Peru, Nebraska.* (*Elected to GQRA, No. 115.*)

If the use of a circular lens calls for a narrow vertical slit down the middle so as to permit light to pass through one third of the area of the lens, what would be the equal distances measured on the horizontal diameter from the center of the lens to the vertical edges of the screen?

Supposing it is desired to have two thirds of the area of the lens transparent with the remaining one third opaque divided equally at edges in the same manner?

SCIENTIFIC OR JUST "COMMON BELIEF"

734. *Proposed by Joseph A. Nyberg, Hyde Park High School, Chicago, Ill.* (*Elected to GQRA, No. 116.*)

On several occasions I have heard that, when making ice-cubes in electric ice-boxes, the trays should be filled with *hot* water *not cold* because hot water freezes faster than cold water. Is this true?

Is there any scientific basis for the statement?

TELEVISION

735. How does "television" work?

(For a simple, popular answer read *Collier's* for November 30, 1935, page 10. No further answer to this question will be published unless readers have some comments to contribute. Ed.)

AN EXAMINATION PAPER

(*Please send in Solutions from pupils for Questions 3, 6, 9, 10,* For a good solution you will be elected to the GQRA.)

736. *Chemistry—College Entrance Examination Board.*

Friday, June 21, 1935. 2 p.m. two hours

Answer eight questions as indicated below.

Number and letter your answers to correspond with the questions selected.

Equations called for in the questions must be balanced in order to receive credit.

Part I

Answer all questions in Part I

1. (*a*) Write the formula for each of the following:
   (1) calcium phosphide;
   (2) barium hypochlorite.

   (*b*) Rewrite each of the following as a balanced equation:
   (1) $FeCl_2+Na_2HPO_4 \rightarrow Fe_3(PO_4)_2+NaCl+HCl$;
   (2) $C_2H_5OH+O_2 \quad \rightarrow CO_2+H_2O$.

(*c*) Write an equation to represent the ionization of:
(1) sodium acid sulphate;
(2) potassium ferrocyanide.
(*d*) Write ionic equations for the reactions that take place when:
(1) aluminum is dipped in cupric sulphate solution;
(2) ammonium hydroxide solution is added to ferric sulphate solution.

2. The preparation of hydrogen is usually accomplished in the laboratory by treating a metal with a moderately dilute solution of an acid.
(*a*) Give the names and symbols of three metals that would be satisfactory for the purpose.
(*b*) Give the names and symbols of two metals that would not be satisfactory and explain why they would not be.
(*c*) Give the names and formulas of three acids that would be suitable.
(*d*) Give the names and formulas of two acids that would not be suitable and explain why they would not be.
(*e*) A certain weight of copper is to be brought into solution as cupric nitrate. Would more, or less, nitric acid be required if it were in *dilute* solution than if it were in *concentrated* solution? Why?

3. Ten liters of hydrogen are mixed with 10 liters of oxygen, both measured at 250° C. and 200 atmospheres pressure. The mixture is ignited and reaction takes place according to the equation

$$2H_2+O_2 \rightarrow 2H_2O.$$

(*a*) What will be the total volume of gases after the reaction, the measurements being made at 250° C. and 200 atmospheres pressure, the water being gaseous?
(*b*) What will be the volume, under the same conditions, of the water vapor alone?
(*c*) Show how to calculate the volume of gas that would remain after cooling the gas mixture to −20° C. and at the same time reducing the pressure to 765 mm. (the actual calculations need not be carried out).

4. (*a*) How would you prove the presence of carbon monoxide, carbon dioxide, and hydrogen in a mixture of the three?
(*b*) What is the ratio of the density of carbon monoxide to that of nitrogen, both at standard conditions? Show clearly the reason for your answer.
(Atomic weights: C=12; O=16; N=14; H=1.)
(*c*) Which will produce more heat per cubic foot when burned, water gas or producer gas, the two being measured under the same conditions? Why?

5. (*a*) Describe the Solvay process for the manufacture of sodium carbonate.
(*b*) Write equations for the reactions taking place in the process.
(*c*) Mention one use for the by-product. Name the property upon which this use depends.
(*d*) Explain why potassium carbonate is not made by the Solvay process.

Part II

Select three questions from Part II

6. Rewrite the following tables, filling in the blanks with the requisite information:

	Name	Formula	Use
(*a*)	Ozone	....	....
(*b*)	....	$HgCl_2$	....
(*c*)	....	....	Making plaster casts
(*d*)	....	SiO_2	....
(*e*)	Chlorinated lime	....	....
(*f*)	....	....	Drying ammonia
(*g*)	....	SiC	....
(*h*)	....	....	Paint pigment
(*i*)	....	....	Anaesthetic
(*j*)	Phosgene	....	....
(*k*)	....	$Pb(C_2H_5)_4$	....
(*l*)	Neon	....	....

7. (*a*) Show by a diagram the structure of the non-luminous flame of the Bunsen burner, indicating:
   (1) the hottest part;
   (2) the oxidizing part;
   (3) the reducing part.
   (*b*) Explain briefly why the parts so indicated have these properties.
   (*c*) Describe carefully how you would make an elbow from a straight piece of glass tubing.
   (*d*) Explain why the flame of an acetylene burner is so brilliantly luminous.

8. (*a*) What is the light-sensitive substance on the photographic plate?
   (*b*) What change takes place in the substance when the plate is exposed?
   (*c*) What change takes place in developing an exposed plate?
   (*d*) What is meant by *fixing*? What fixer is usually employed?
   (*e*) What two purposes does the gelatin serve?

9. (*a*) Two solutions are prepared, one by dissolving 10 grams of sodium chloride in 100 grams of water, the other by dissolving 10 grams of sugar ($C_{12}H_{22}O_{11}$) in 100 grams of water. Which solution has the higher boiling point? Explain.
   (*b*) Which would conduct the electric current better, a molar solution of sodium chloride or a molar solution of ferric chloride? Explain.
   (*c*) What volume of 0.2 molar barium hydroxide solution would neutralize the solution made by dissolving 2.24 liters of gaseous hydrogen chloride in water, the volume being measured at S.T.P.?
   (Atomic weights: Na = 23; Ba = 137; C = 12; O = 16; H = 1; Cl = 35.5; Fe = 56.)

10. Give the reason for the explosion which occurs when:
    (*a*) a cylinder of carbon dioxide bursts during a fire in the building in which it is stored;
    (*b*) gunpowder is ignited;
    (*c*) sodium is thrown on water;
    (*d*) liquid oxygen comes in contact with lubricating oil;
    (*e*) an electric spark ignites flour dust in a flour mill;
    (*f*) a mixture of hydrogen and chlorine is exposed to direct sunlight.

11. Four raw materials are used in the blast-furnace process for the extraction of iron from its ores.
    (*a*) State briefly the function of each raw material.
    (*b*) Explain the effect on the process of the water which usually accompanies the raw materials.

(c) What are the two chief by-products of the process? Mention a use for each.
(d) Name four elements usually present as impurities in the iron produced in the blast furnace.
(e) Why cannot aluminum be made by the blast-furnace process?

Have you answered *three* questions in Part II? If you have answered more than three questions in Part II, cross out the one or ones that you do not wish to have count.

SOME QUESTIONS YOU HAVE MISSED

Nos. 624, 675, 676, 703–709, 717, 725.

TEACHERS!!! *Put up these problems and questions to your classes.*

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BOOKS AND PAMPHLETS RECEIVED

Sound, by Floyd Rowe Watson, Professor of Experimental Physics, University of Illinois, and Editor of Journal, Acoustical Society of America. Cloth. Pages ix+219. 14.5×23 cm. 1935. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.50, plus postage.

Our Government Today, by Finla Goff Crawford, Professor of Political Science, School of Citizenship and Public Affairs, Syracuse University. Cloth. Pages viii+354. 11.5×19 cm. 1935. Henry Holt and Company, One Park Avenue, New York, N. Y. Price 96 cents.

A Textbook of Physics, Volume V, Physics of the Atom, by E. Grimsehl; Edited by R. Tomaschek, Director of the Physical Institute, Technical College, Dresden; and Authorized Translation from the Seventh German Edition by L. A. Woodward, Leipzig. Cloth. Pages xiv+474. 14.5×22 cm. 1935. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 17s. 6d. net.

The Invertebrata, by L. A. Borradaile, Fellow of Selwyn College, Cambridge; F. A. Potts, Fellow of Trinity Hall, Cambridge; with Chapters by L. E. S. Eastham, Professor of Zoology in the University of Sheffield, and J. T. Saunders, Fellow of Christ's College, Cambridge. Second Edition. Cloth. Pages xv+725. 14×22 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

The Book of Minerals, by Alfred C. Hawkins, Soil Expert, Soil Conservation Service, U. S. Department of Agriculture. Cloth. Pages xii+161. 13×19 cm. 1935. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.50, plus postage.

Practical Shop Mathematics, Volume II—Advanced, by John H. Wolfe, Supervisor of Apprentice School, Ford Motor Company, and Everett R. Phelps, Associate Professor of Physics, Wayne University. First Edition. Cloth. Pages xiv+628. 12×20 cm. 1935. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.20.

Tests and Measurements in Industrial Education, by Louis V. Newkirk, Director Industrial Arts, Chicago Public Schools, and Lecturer, College of Education, Northwestern University, and Harry A. Greene, Associate Professor of Education and Director of Bureau of Educational Research and Service, University of Iowa. Cloth. Pages x+253. 14.5×23 cm. 1935. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.75, plus postage.

Individualizing Education, by J. E. Walters, Director of Personnel, Schools of Engineering, and Professor of Personnel Administration, Purdue University. Cloth. Pages xvi+278. 14.5×22.5 cm. 1935. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.50, plus postage.

Study Arithmetics, Grade Four, by F. B. Knight, J. W. Studebaker, G. M. Ruch, and W. C. Findley. Cloth. 352 pages. 13×19 cm. 1935. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill.

Study Arithmetics, Grade Five, by F. B. Knight, J. W. Studebaker, and G. M. Ruch. Cloth. 352 pages. 13×19 cm. 1935. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill.

Apprentice Training, by Louis Q. Moss, Instructor-in-Charge of Related Subjects, Philadelphia Navy Yard. Reprinted from Marine Engineering and Shipping Age, October 1935. 9 pages. 21.5×29 cm. Louis Q. Moss, Instructor, Philadelphia Navy Yard, Philadelphia, Pa. Price 15 cents.

The Clock of the Earth, by A. A. Alles. Paper. 18 pages. 12×18 cm. 1935. A. A. Alles, 1413 Federal Street, Pittsburgh, Pa.

The Deserted Village, No. 6, Petroleum Shortage and Its Alleviation, by L. C. Snider and B. T. Brooks. Paper. 38 pages. 13×19 cm. 1935. The Chemical Foundation, 654 Madison Avenue, New York, N. Y.

BOOK REVIEWS

A Mathematician Explains, by Mayme I. Logsdon, Associate Professor of Mathematics, The University of Chicago. Pages xi+175. 17×23.5 cm. Cloth. 1935. The University of Chicago Press, Chicago, Illinois. Price $2.00.

At the University of Chicago, since 1930, a course of three lectures per week for one year in the physical sciences, paralleled with small-group discussions, is required of all students. This course is designed to give the student in some detail explanations of phenomena in the physical world and the history of the development of the explanations.

Since mathematics has played an important part in the development of the physical sciences it is fitting that some time should be devoted to a discussion of this ancient and fundamental subject. Accordingly an attempt is made "to give in a few lectures a vivid picture of the historical development of the mathematics of classical times with a description of types of problems which led to the growth of elementary concepts of arithmetic, algebra, geometry, and trigonometry, and to give something of the purport and processes of the modern subjects, analytical geometry and the calculus, to the end that the student may obtain fairly definite ideas of their meanings and uses in modern life and of their relations to the various fields of the physical sciences." Since few satisfactory references can be found to cover the ground as outlined the book under discussion has been written to meet this need.

The book is divided into eight chapters. The first chapter is entitled "The Nature of Mathematics." This chapter discusses the fact that mathematics is an abstract science and explains the nature of deductive reason-

ing. The second chapter on "Arithmetic" presents in an interesting manner the following topics: The principle of position and the important rôle zero plays in a number system; base of a number system; the structure of a number system; historical notes on the evolution of number concepts; classification of numbers, operations of arithmetic; logic of arithmetic; early arithmetic; and computing machines. In the third chapter on "Algebra" we find a discussion of form, importance of symbolism, equation, and approximate solutions. The fourth chapter on "Geometry and Trigonometry" gives a historical background of these subjects. It also defines the trigonometric functions and points out a number of their applications. The next three chapters deal with some of the fundamental concepts and processes of analytical geometry, differential calculus, and integral calculus. Chapter 8 on "Mathematical Interpretations of Geometrical and Physical Phenomena" was written by Professor Gilbert A. Bliss. In this chapter we find discussions of the following topics: Geometrical Measurements, Fundamental Postulates of Geometry, A Simple Non-Euclidean Geometry, The Structure of a Mathematical Science, Mathematical Theories in Astronomy, and Mathematical Theories in Physics.

In an appendix we find some material on algebraic manipulation and the laws of sines, cosines, and exponents. This material is to be used by readers who have not recently been engaged in mathematical computation.

The book does not take the place of any one of the texts in standard courses of college mathematics. The sponsors believe that it will be useful along the following lines:

(1) To provide the mathematics for general physical science courses.

(2) To serve as a text for a one-hour or a two-hour orientation course in college, junior college, or senior high school.

(3) To serve as a reading reference for first-year and second-year mathematical courses in college or junior college.

(4) To serve as a supplementary text for courses in the teaching of mathematics in normal schools and teachers colleges.

(5) To serve the adult who has but little knowledge of mathematics but who wishes to get some information about the science which has made possible this machine age.

The reviewer believes there is another large group which would be interested in this unusual book, viz., the teachers of mathematics and science in the junior and senior high schools. Every high school, college, and public library should be well stocked with it.

J. M. Kinney

Mathematics and the Question of Cosmic Mind With Other Essays, by Cassius Jackson Keyser, Adrain Professor Emeritus of Mathematics, Columbia University. Cloth. Pages v+121. 12.5×19 cm. 1935. Published by Scripta Mathematica, Yeshiva College, Amsterdam Avenue and 186th Street, New York, N. Y.

This little book is a compilation of six essays by Professor Keyser recently published in periodicals. The first three, The Meaning of Mathematics, The Bearings of Mathematics, and Mathematics and the Question of Cosmic Mind, form a logical sequence. The last three, Mitigating the Tragedy of our Modern Culture, On the Study of Legal Science, and William Benjamin Smith, are independent units.

In the first essay the author sets forth the thesis that mathematics is the enterprise having for its aim to establish hypothetical propositions. Mathematics is put in contrast to science which is defined as the enterprise having for its aim to establish categorical propositions.

In the second essay we find a discussion of the "bearings" of mathematics on such human interests and concerns as ideals, logical rectitude, art of exposition, relations, change, invariance, logical criticism, pragmatism, infinity, and religion.

In the third essay this question is raised: What evidence, if any, does mathematics furnish to support the thesis that our universe is, essentially and fundamentally, a realm of mind? The word Mathematics is used here in a very broad sense to include "sheer" mathematics, the applications, and the bearings of mathematics.

The fourth essay discusses the problem of "so presenting and so expounding scientific and mathematical ideas, scientific and mathematical methods, and scientific and mathematical achievements, together with their philosophical implications and spiritual significance, as to engage the interest and reach the understanding of intellectual laymen."

The fifth essay discusses the problem of creating a legal science and the rôle of mathematics in its study. The sixth essay is a tribute to William Benjamin Smith who was a "mathematician, physicist, poet, philosopher, historian, teacher, and critic."

This book is written for the intellectual layman. However, the reviewer believes that teachers of science and mathematics will find in it much food for thought.

J. M. Kinney

Introductory College Mathematics, by William E. Milne, Professor of Mathematics, Oregon State College, and David R. Davis, Associate Professor of Mathematics, State Teachers College, Mont Clair, New Jersey. Cloth. Pages xiv+383+ii+64. 15×23 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $3.00.

During the past three decades many teachers of college mathematics have come to the conclusion that the so-called standard courses of freshman mathematics do not function efficiently in the mathematical development of the student. During this period many attempts have been made to organize the freshman offering so as to present an integrated whole. A large number of books have been published. In the preface of one of these books which is a pioneer in the attempted reform we find this statement:

"In arranging the material the traditional division of mathematics into distinct subjects is disregarded, and the principles of each subject are introduced as needed and the subjects developed together. The objects are to give the student a better grasp of mathematics as a whole, and of the interdependence of its various parts, and to accustom him to use, in later applications, the method best adapted to the problem in hand. At the same time a decided advantage is gained in the introduction of the principles of analytic geometry and calculus earlier than is usual." (Woods and Bailey, *A Course in Mathematics*. 1907.)

The statement just quoted, written nearly thirty years ago, summarizes very well the point of view of a fast growing number of college mathematics. The text under review is written by men who believe strongly in this statement.

Three fundamental concepts govern the selection and organization of the material, namely: the function concept, the concept of an equation, and the concept of a locus; of these three the first is dominant. The contents may be grouped as follows:

Part A. Elementary Algebraic Functions. Chapters I-VIII.
Part B. Logarithms and Trigonometry. Chapters IX–XIII.
Part C. Elementary Transcendental Functions. Chapters XIV–XVI.
Part D. Analytic Geometry and Determinants. Chapters XVII–XXI.

Part E. Additional Topics in Analytic Geometry. Chapters XXII–XXIV.
Part F. Additional Topics in Algebra. Chapter XXV.
Part G. Approximations and Curve Fitting. Chapter XXVI.
Enough material is provided to occupy an average class meeting five times a week for a period of one college year.

The course is greatly enriched by the early introduction of the calculus and its continued application. It is suitable not only for college freshman but also for senior high school classes.

J. M. KINNEY

A Textbook of Algebra, by William H. H. Cowles and James E. Thompson, Department of Mathematics, School of Science, Pratt Institute. Cloth. Pages xi+402. 15×23 cm. 1935. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.25.

We find in this text twelve chapters which comprise the usual topics of the standard college algebras. The first chapter includes the material which is usually covered in the high school algebra. This material is placed there for review or reference.

We might infer after a glance at the table of contents that we have here just another college algebra. However, a closer inspection discloses some features which differentiate it from the common run. In the first place we notice the unusual size of the book. There are over four hundred large pages. This unusual size is due to the fact that the authors have undertaken the task of writing a text which could be read by students. For those of us who believe that a college student of mathematics should be taught to read mathematics, this is a commendable feature.

Much attention is given to the construction and use of graphs. There is a chapter on the use of the slide rule. The solution of equations of degree higher than the second is postponed to the last chapter. Here we find the general solutions of the cubic and the quartic. Instead of the usual Horner's method of solution of numerical equations of higher degree, we find Graeffe's method.

J. M. KINNEY

Modern School Mathematics, by Ralph Schorling, Head of Department of Mathematics, The University High School, and Professor of Education, University of Michigan; John R. Clark, The Lincoln School of Teachers College, Columbia University, with the cooperation of Rolland R. Smith, Specialist in Mathematics, Public Schools, Springfield, Mass. Cloth. 12.5×18.5 cm. Book I, pages xx+364. Book II, pages xvi+368. 1935. World Book Company, Yonkers-on-Hudson, New York. Price each 92 cents.

These modern texts have been prepared for the 7th and 8th grades. They are revisions of an earlier text, the superior features and general plan of which have been retained.

These books present mathematics in a meaningful way so that the pupil can understand and use it. This is accomplished by relating mathematics to the pupils' interests and activities.

Problem solving has been made one of the chief aims of the course. The verbal problems are always true problems that is problems that occur in life. Differentiated problems are provided so that each pupil may work at a level at which he will be successful.

Realizing that students need drills in the fundamentals of arithmetic to maintain and increase their skill the authors have provided ample drill exercise and have included in the material diagnostic tests which reveal to the pupil his specific weaknesses.

The authors have produced a fine set of texts that are a definite step forward in the reconstruction of the mathematics curriculum.

GEO. L. ROYCE

First Course in Algebra, by C. Newton Stokes, Teachers College, Temple University, Philadelphia, Pennsylvania, and Vera Sanford, State Normal School, Oneonta, New York. Cloth. Pages v+439. 12.5×19 cm. 1935. Henry Holt and Company, One Park Avenue, New York, N. Y. Price $1.28.

Progressive teachers of mathematics will be interested in this modern algebra text because it has many commendable features. Among them are: (1) A clear statement of purpose introduces each chapter, (2) frequent illustrations and diagrams, (3) review exercises, (4) mastery tests, (5) summaries, (6) plenty of exercises, (7) geometry is used whenever possible to make the algebraic symbols meaningful, and (8) inclusion of a chapter on the elements of trigonometry.

GEO. L. ROYCE

A Second Course in Algebra, by N. J. Lennes. Cloth. Pages ix+390. 13×20 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.36.

This text is a sequel to *A First Course in Algebra* which was reviewed recently. However the text can easily be used for a second course even though *A First Course in Algebra* is not used. This text is constructed along the same line as the first book. One of the excellent features of the text is the great amount of problem material and the supplementary material for the brighter classes and the more ambitious pupils.

The reviewer feels that teachers of mathematics will be interested in this text.

GEO. L ROYCE

The Voyage of Growing Up, by C. E. Turner and Grace T. Hallock. Cloth. 202 pages. 13×19 cm. D. C. Heath and Company, New York. Price $0.60.

In Training for Health, by C. E. Turner and Jeanie M. Pinckney. 152 pages. Price $0.60.

Community Health, by C. E. Turner and Georgie Collins. 250 pages. Price $0.84.

Physiology and Health, by C. E. Turner, Professor of Public Health, Massachusetts Institute of Technology. 278 pages. Price $0.96.

These little books are so pleasingly constructed and so attractively written that they are bound to arouse the imagination, initiative, and judgment of the children. Throughout the series sound health practices and right attitudes of both individual and community health are emphasized. Structure is presented by diagram alone. Motivation is provided by introducing each chapter with a list of questions and suggested activities. *The Voyage of Growing Up* and *In Training for Health* are of fourth and fifth grade level. *Community Health* and *Physiology and Health* are eighth and ninth grade books.

C. RADIUS

The Nature Hour, by Lucille Nicol, Assistant Superintendent of Public Schools, Samuel M. Levenson, Principal of Public Schools, and Teressa Kahn, Teacher of Nature Study, Public Schools, New York City. Cloth.